VOL. 36, NO. 8 AUGUST, 1959

AMERICAN JOURNAL OF OPTOMETRY *and* ARCHIVES *of* AMERICAN ACADEMY OF OPTOMETRY

EDITOR
CAREL C. KOCH

EDITORIAL COUNCIL
JOHN D. PERRY, JR. Chairman
ROBERT E. BANNON
RUDOLPH EHRENBERG
V. J. ELLERBROCK
BENTON FREEMAN
GLENN A. FRY
ROBERT GRAHAM
MONROE J. HIRSCH
HENRY W. HOFSTETTER
MEREDITH W. MORGAN
HENRY B. PETERS
MAX SCHAPERO
ARTHUR SHLAIFER
KENNETH B. STODDARD
RALPH E. WICK
JOHN ZETTEL

CONTENTS

ORIGINAL PAPERS

Changes in Astigmatism After the Age of Forty. *Monroe J. Hirsch* 395

Referrals from Visual Screening of School Children. *Vernon Ryan* 406

Signal Color Recognition by Color Defective Observers. *Gordon G. Heath and Ingeborg Schmidt* 421

EDITORIAL

Presenting a Review of Academy Post-Graduate Courses. *Carel C. Koch* 438

TRANSACTIONS OF THE ACADEMY

Post-Graduate Courses of the American Academy of Optometry, Chicago, December 9, 10, 11, 1959 at the Drake Hotel. *V. J. Ellerbrock, et al* 439

BOOK REVIEW

Vision Screening for Elementary Schools: The Orinda Study, by H. L. Blum, H. B. Peters and J. W. Bettman. *Charles R. Stewart* 449

SPECIAL REPORT

Gold in Optometric Attics. *Harriette M. Cluxton* 450

CURRENT COMMENTS

Notes from Schools and Colleges. *Terry Judith Parkins* 453-454

Published Monthly by the AMERICAN JOURNAL OF OPTOMETRY PUBLISHING ASSOCIATION, 1508 Foshay Tower, 821 Marquette Ave., Minneapolis 2, Minn.

ANNUAL SUBSCRIPTION, UNITED STATES and CANADA $8.00; FOREIGN $9.00.
Single Copies, 80c

Entered as second-class matter, February 20, 1934, at the post office at Minneapolis 2, Minnesota, under the Act of March 3, 1879.
Established 1924.

It's New!

The KUROVA F FUSED TRIFOCAL

Here's another addition to the Kurova F line of fine fused multifocals . . . Continental's new Kurova F corrected curve trifocal.

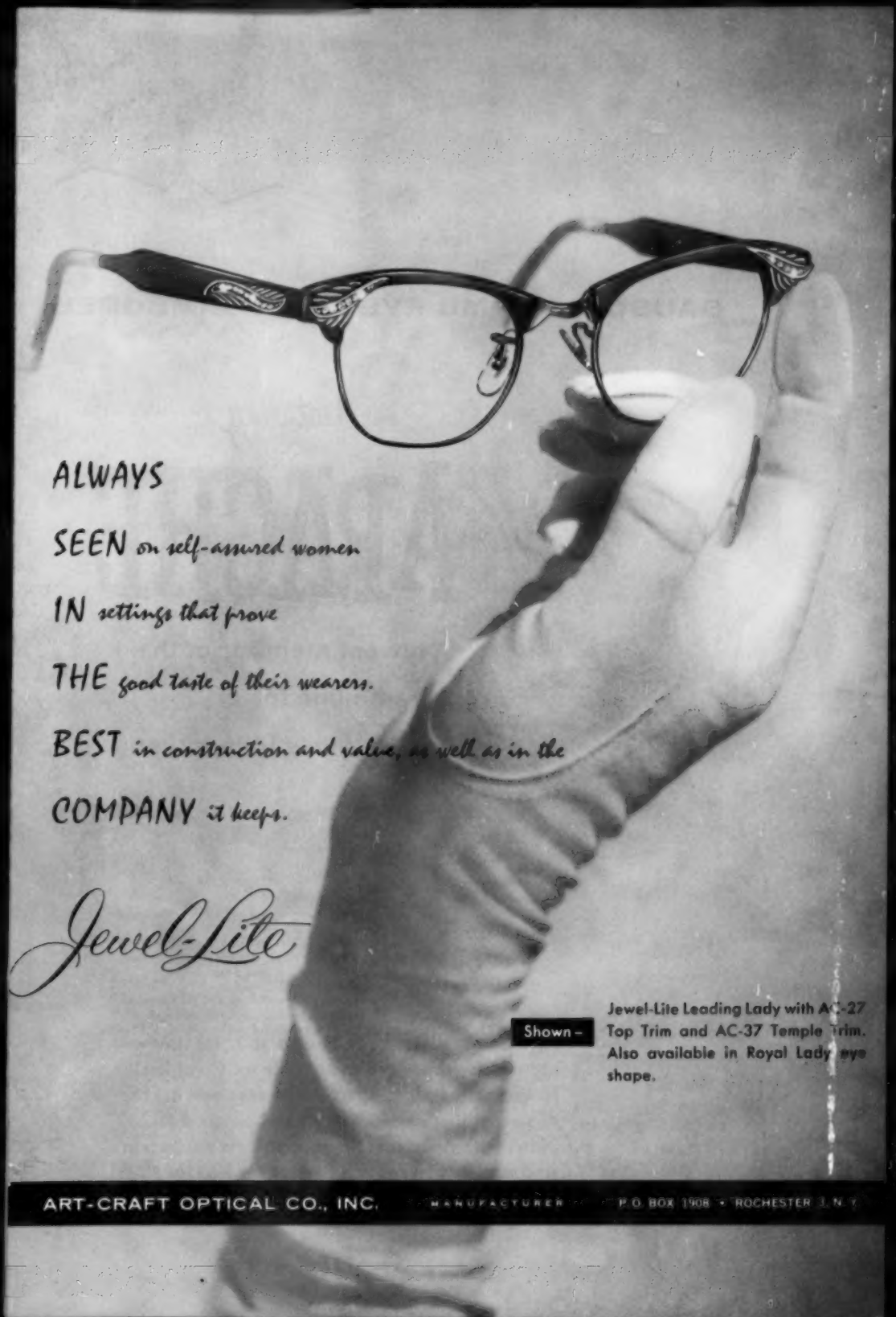
Produced in the popular 23 m/m and 25 m/m segment widths, the Kurova F trifocal features the favorite 7 m/m intermediate segment depth, designed at 50% the power of the reading seg.

Best of all, the F trifocal is *both* "optically" and "cosmetically" designed. "Optically" designed because of its Continental quality and corrected curve structure; "cosmetically" designed because it's been made in the popular style with coated, yet inconspicuous lines.

Try the new Kurova F fused trifocal. The nicest thing we can say about it is "It's a typical lens by Continental."

Remember the Kurova F fused bifocal, too . . . corrected curve design in 20 m/m, 22 m/m and 25 m/m segment sizes.

Continental
INDIANAPOLIS


ALWAYS
SEEN on self-assured women
IN settings that prove
THE good taste of their wearers.
BEST in construction and value, as well as in the
COMPANY it keeps.
Jewel-Lite
Shown –
Jewel-Lite Leading Lady with AC-27 Top Trim and AC-37 Temple Trim. Also available in Royal Lady eye shape.
ART-CRAFT OPTICAL CO., INC.
MANUFACTURER
P.O. BOX 1908 • ROCHESTER 3, N.Y.

BAUSCH & LOMB EYEWEAR JAMBOREE

featuring

APACHE

Newest member of the
B & L frame line for
lively little Indians

APACHE is available in Black Briar|Crystal, Brownwood|Crystal, Bronze-Lite and Smoke-Lite.

Apache rounds out the Bausch & Lomb line of eyewear for the rough and tumble set. Completely new in basic design, Apache achieves a new degree of strength, of comfort, of masculine good looks. Now, with Apache in the line, you get a selection so complete you can standardize on B&L quality exclusively for all your juvenile eyewear needs.

GENESEE JR. • The handsome saddle bridge number . . . now in Golden Briar| Crystal and Castlewood|Crystal, and the same colors solid.

BALRIM JR. • Junior edition of the popular men's Balrim. In Golden Briar with Arista, and in Blonde with Arista.

TINKER BELL • Another popular number among young maidens is this saddle bridge number. In Peri-Red, Peri-Blue, Sky Mist and Cin Mist, all on Crystal.

SCHOOL BELLE CLEAR BRIDGE
Continues to be the hit of the school set. With keybole bridge, in Sparkle Blue, Sparkle White, Sparkle Brown, all on Crystal.

Frames by BAUSCH & LOMB

RIGHT IN FASHION . . . RIGHT IN FUNCTION

Everything you want for the BACK-TO-SCHOOL needs of your younger patients

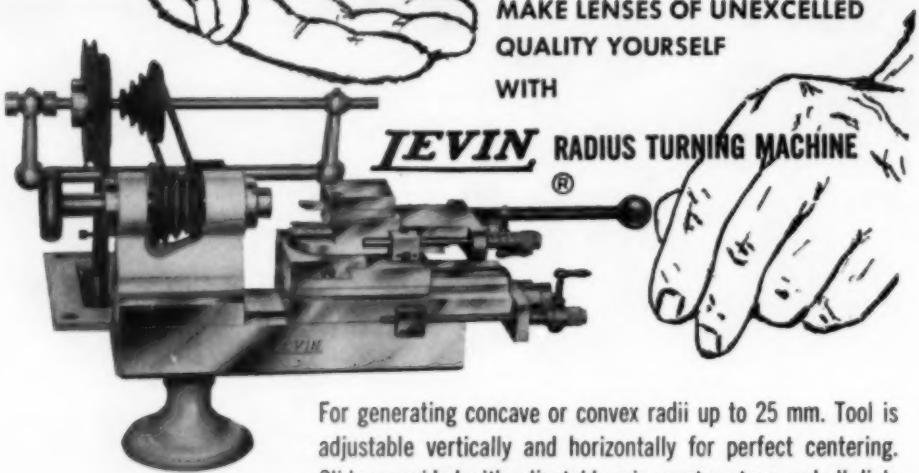
QUALITY MAKES THE DIFFERENCE

IN FITTING · SELLING and WEARING

PLASTIC **CONTACT LENSES**

MAKE LENSES OF UNEXCELLED QUALITY YOURSELF WITH

LEVIN RADIUS TURNING MACHINE ®



For generating concave or convex radii up to 25 mm. Tool is adjustable vertically and horizontally for perfect centering. Slides provided with adjustable micrometer stops and all dials graduated to .01 mm. The upper slide is used to turn the desired radius. The lower slide regulates the depth of cut on center thickness of the lens without affecting the radius.

WE SUPPLY EVERYTHING

The lens making unit consists of the radius turning machine and a lathe for polishing, complete on one bench, ready for immediate use. We also furnish lens blanks, polishing laps and all accessories required for making a lens. This same equipment is used by leading laboratories throughout the country for making high quality contact lenses.

SOLEX LABORATORIES, INC.
Representatives
530 N. La Cienega Blvd.
Los Angeles, California

Send for special descriptive literature on radius turning machine, laboratory tools and accessories

LOUIS LEVIN & SON, INC., 3610 South Broadway, Los Angeles 7, California

"MAKERS OF WORLD'S FINEST WATCHMAKERS LATHES"

Isn't it time to look at eye care costs?

Today a patient pays only 16.7% more for eye care, on an average, than he did during the 1947-1949 period. This compares with . . .

General Practitioners' fees	up	41.1%
Tonsillectomies	up	29.7%
Hospital rates	up	101.1%
Dental extractions	up	36.9%
Appendectomies	up	20.7%
Dental fillings	up	32.7%
Obstetrical fees	up	56.6%

Doesn't this indicate that eye care is one of today's best buys?

Yes—from the patients' point of view. But unfortunately a professional man's living expenses are up 23.7%. And the cost of maintaining the average professional office is continually increasing.

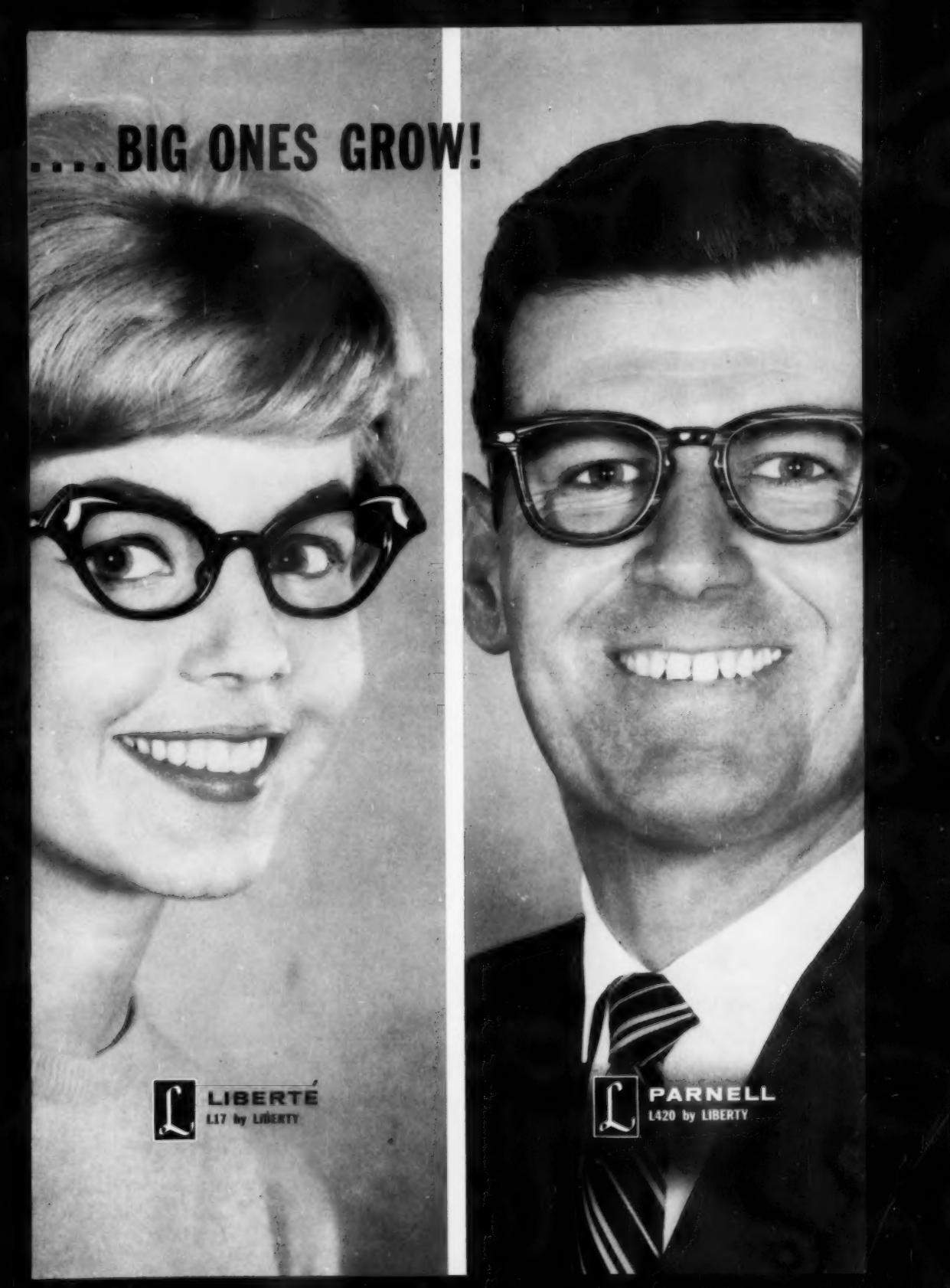
What about the future?

It depends on each individual. Naturally, fees should be realistically related to the quality of professional services offered, to the costs of providing them and to the prices people are willing to pay. This question deserves the best thinking of the Eye Care Professions in order that top caliber men may continue to be attracted to, and encouraged to stay in, the Eye Care Professions.

NOTE: Figures based on U.S. Consumer Price Index figures to December 1958

American Optical
COMPANY
Since 1833 . . . Better Vision for Better Living

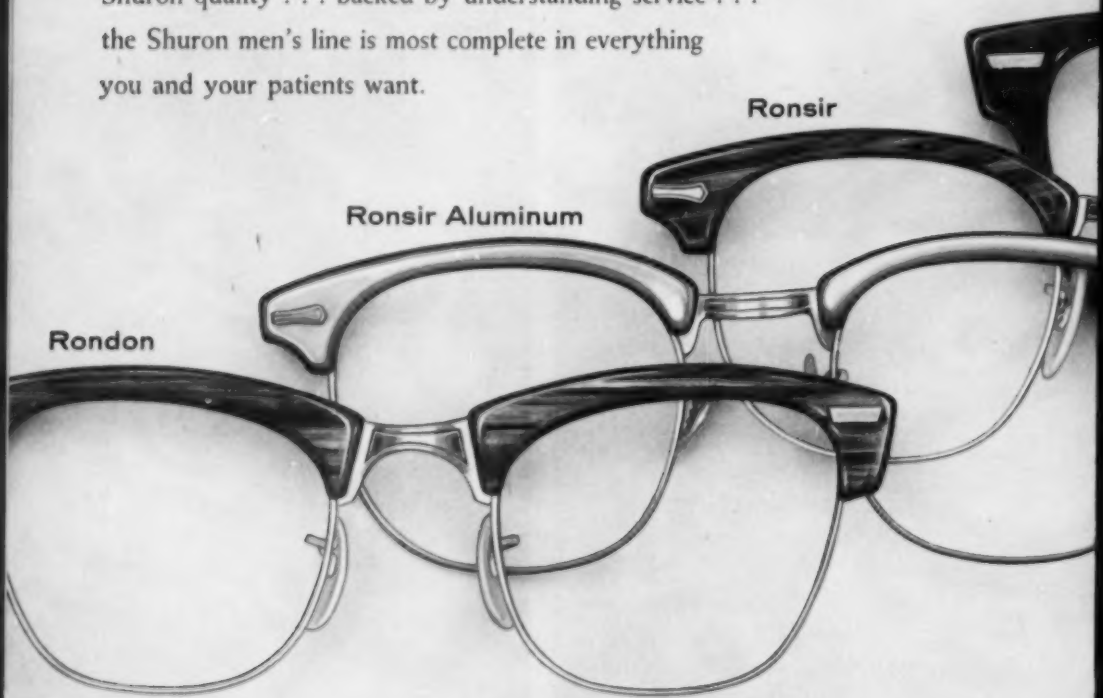
from little patients..
PAR KEYHOLE JR.
L320 JR. by LIBERTY
MISS LIBBY TINSEL
L200 JR. by LIBERTY


....BIG ONES GROW!
LIBERTÉ
L17 by LIBERTY
PARNELL
L420 by LIBERTY

First in Choice...

Consider the new completeness of your Shuron men's selection—
the range it presents in styles, colors, sizes, and temples . . .

By far the most popular with both professional and patient . . . offering significantly more in fitting, comfort and appearance . . . representing dependable Shuron quality . . . backed by understanding service . . .
the Shuron men's line is most complete in everything
you and your patients want.



IN STYLES

Now, a *choice* in men's combinations—the contemporary new Rondon Browline® Frame at the left; next, Ronsir in anodized aluminum; then Ronsir in zylonite. At the right, a choice in all-zyl styles—the solid color Rondean, or the popular Rondean Clear Bridge. A Shuron frame for every face, and a price for every patient's pocketbook.

IN COLORS

Four colors for the new Rondon—Black Briar, Golden Briar, Briar Grey and Cordova; five in aluminum for Ronsir—Brown, Bronze, Sienna, Gunmetal and Ebony (in addition to eight in zylonite); five for Rondean and Rondean Clear Bridge – Dusk Grey, Dusk Brown, Briar Grey, Black Briar, Golden Briar—plus Ebony for Rondean solid.

IN SIZES

A complete range of sizes is available in all five styles—from 44 to 48mm (18-24 bridge), and 50mm (20-24). In addition, Ronsir is obtainable in 38mm (18-22), 40mm (18-24), 42 to 50mm (26) and, in aluminum, 42 to 50mm.

IN TEMPLES

A compiete choice of matching or harmonizing styles includes Slipper, Taper, Riding Bow, Relaxo, Aztec Library, Aztec Relaxo, and aluminum Panel styles for Ronsir; Academy and Imperial for the Rondeans, and Oxford for Rondon.

SHURON®

the complete men's wear line

IN QUALITY

Shuron *means* quality. With the highest standards in zylonite, in 1/10 12K gold filled, in anodized aluminum . . . in precision forming, skilled craftsmanship and unsurpassed finish . . . in accuracy of fit, interchangeability of components, and performance, you can always depend upon Shuron's famous "Quality Beyond Question."

IN SERVICE

Our whole production and distribution organization is built upon the concept of *complete* service to the profession. Our home office and coast-to-coast branch staffs work together with a network of professional suppliers to provide you with the styles, sizes and colors you want—where and when you need them.

Consul Reception Room Furniture: Chair, Sectional Sofa (*right or left*), Square Corner Table, Frame Display Coffee Table

CONSUL—Smart professional furniture

NEW SMALLER TABLE FOR FITTING ROOMS
CONSUL "space-saver" dispensing table—36″ x 18″ x 29½″ high—provides maximum work areas. In stained walnut, mahogany, black birch, natural birch.

Smart, new CONSUL professional furniture puts your patients at ease the moment they step into your office . . . makes their *entire* visit more enjoyable—from reception room through fitting room. CONSUL's clean-lined styling and beauty convey dignity and taste. And its sound functional design and sturdy construction assure years of service. Available in a variety of contemporary wood or metal finishes. Of course, the background for your CONSUL furniture is important, too. That's why AO provides a *free* Planning and Decorating Service. You get a custom-tailored office plan and furniture arrangement suggestion tailored to your specific needs. And you get professional decorating help that embraces suggested colors,

Consul Fitting Room Furniture: Frame Display Bar, Frame Fitting Table, Patient Chair, Dispenser Chair

for years of successful practice

drapery materials, floor coverings, and decorative accessories. Whether you are remodeling your present office, or furnishing a new office, CONSUL professional furniture can be yours at surprisingly low cost. (You can take up to five years to pay by using American Optical's Easy Payment Plan.) Let us show you how simple it is to have the kind of office you and your patients will admire for years. Mail the coupon today for our new booklet that gives full details.

American Optical
COMPANY

Since 1833 ... Better Vision for Better Living

American Optical Company
Dept. 4631-D
Southbridge, Mass.

Please send your free booklet "Professional Furniture and Equipment for the Eye Care Professions" to:

*Name*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

make protection a part of every prescription

Every lens must withstand the impact of a ½" steel ball dropped from a height of more than 4 feet.
THESE ARE GENUINE
HARDRx*
SAFETY LENSES
* prescribed for that important margin of safety for your eyes

BENSON'S HARDRx SAFETY LENSES!

Eyes worth correcting are worth protecting. Every one of your patients *deserve* maximum safety from dangerous and costly lens breakage. Benson's HARDRx safety lenses – ground to a formula-determined thickness and scientifically heat treated – are toughened to resist impact.

To impress on your patients that you've prescribed the ultimate in lenses for them, the identifying tag shown at left is attached to each pair of genuine HARDRx lenses. Your patients will appreciate your thoughtfulness in prescribing this extra protection . . . and will tell their friends of your quality service.

Join the growing number of doctors who specify HARDRx regularly. Remember: HARDRx prescriptions receive the same prompt handling.

1913-1959 . . . Our 46th year

BENSON OPTICAL COMPANY

Executive Offices • 1812 Park Avenue, Minneapolis

specialists in prescription optics since 1913

COMPLETE LABORATORIES CONVENIENTLY LOCATED IN UPPER MIDWEST CITIES

AMERICAN JOURNAL OF OPTOMETRY
and ARCHIVES *of*
AMERICAN ACADEMY OF OPTOMETRY

Vol. 36 August, 1959 No. 8

CHANGES IN ASTIGMATISM AFTER THE AGE OF FORTY*

Monroe J. Hirsch†
Ojai, California

In a previous paper describing the spherical refraction of patients over the age of 45, we stated that "a study of the changes in degree and axis of astigmatism in this same age range would be worthy of consideration . . ."[1] The present paper is such an investigation. In our earlier paper we pointed out that among many older patients, particularly past 75 years of age, there is slowing of the mental processes, denser media, smaller pupils making for poor retinoscopic reflexes, and deafness—all of which make optometric subjective testing difficult. Therefore, any knowledge which optometrists can acquire regarding the changes in refraction which usually occur might be of value in trying to help these patients.

That "with-the-rule" astigmatism is most prevalent among the younger and "against-the-rule" among the older patients is well known and is a concept almost (but not quite) as old as scientific refraction itself. So much of present day clinical optometry begins with Donders, "The Father of Modern Refraction," that it is interesting indeed to find any phase of the subject which the old master had not solved. Here, however, we seem to have one as the following paragraph will indicate.[2]

> As to time of life, it is evident that this can have no influence. So long as the power of accommodation remains active, the disturbance of vision from a moderate degree of astigmatism is, however, productive of less inconvenience. Slight cases, therefore, usually first present themselves, when the range of accommodation (about the thirtieth year) is already perceptibly diminished, while in high degrees of astigmatism the disturbance is early remarked, and the ophthalmic surgeon is not unfrequently consulted even before the patient has attained his seventh year. On the other hand, at an advanced period of life, in consequence of the diminution of the pupil, a certain degree of astigmatism produces less disturbance. With all this the astigmatism certainly maintains about its original degree.

Helmholtz,[3] on the other hand, was well aware of the phenomenon. He states, "The limit of normal astigmatism of the eye probably should be given as 0.5 dptr., the direct form being more common in youth and the inverse form ("against-the-rule") in more advanced life."

Sheard[4] presents a graph attributed to Faehndrich in which is presented the percentage of persons with direct and with inverse astigmatism at each decade of life. The following percentages were read from this graph and, while only approximate, they do demonstrate the trend:

---

*Read before the annual meeting of the American Academy of Optometry, Chicago, Illinois, December 13, 1958. For publication in the August, 1959, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist, Ph.D. Fellow, American Academy of Optometry.

Decade of Life	Direct Astigmia	Inverse Astigmia
4th	78	22
*5th	58	35
6th	48	52
7th	22	78

*It will be noted that the percentages for the fifth decade do not total 100 per cent. This is probably an error in the original drawing since the figures could not be "fudged" in reading to make them come any closer to 100 per cent.

Duke-Elder,[5] summarizes the work of earlier authors, particularly of Jackson, and concludes:

> There is a general tendency for the direct astigmatism (the usual condition at birth) to decrease or inverse astigmatism to increase, but the changes are within narrow limits . . . It follows that a young adult aged 30 with a small amount of direct astigmatism may become stigmatic at 45 and is likely to show some inverse astigmatism at 60 years . . .

Kratz and Walton[6] studied a group of patients (295 eyes) examined on more than one occasion over a period of between 10 and 20 years. The average length of time between first and last visit was approximately 14 years. During this period "the subjective cylinder did not change more than ±0.25 D. in 60.2 per cent of the cases." In spite of this seeming absence of change, when the data of these authors were analyzed in a fashion similar to that of Faehndrich, similar results were obtained. The following table lists the approximate percentages presented in graphical form by Kratz and Walton:

Decade of Life	With-the-Rule Astigmatism	Against-the-Rule Astigmatism	No Astigmatism
4th	58	18	24
5th	57	22	22
6th	45	34	22
7th	32	37	31
8th	37	41	24
9th	0	100	0

Similar results by Walton[7] were obtained in a later study of 1249 patients seen an average of five times over a time range of five to 39 years. The findings are summarized as follows: "The cylindrical findings, regardless of the number of years between the first and last visit, show a change of 0.00 D. This differs from the usual idea of an increase in astigmia with age, but is in agreement with the finding of Kratz and Walton."

This seeming paradox is not easy to interpret. In the longitudinal studies, Kratz and Walton, and later Walton, found no change in the average degree of astigmatism. Yet, when their results are considered by decade they reveal a clear decline in the number of patients showing with-the-rule astigmatism and an increase in the number of patients

showing against-the-rule astigmatism as age increases. Our present study, being non-longitudinal, can throw little light upon this interesting phenomenon. It does, however, present a close and careful analysis of the incidence of the various types of astigmatism at various ages.

Present Study: The subjectively determined cylindrical lenses for a group of 1,606 eyes are the basic data for this investigation. Clinic record cards from the author's optometric practice were selected from the alphabetically arranged file in the following manner: The data were recorded on tabulation sheets with a separate sheet for each five year grouping, beginning with age group 40-44, and on up to the group "Over 80." Each eye was recorded separately. When a sheet contained 200 entries, no further data were accumulated for this category since it was felt that a group of 200 eyes was sufficiently representative of each age. In this manner, data on 200 eyes were obtained for the first six groups, 175 eyes for the 70-74 group, 128 eyes for the 75-80 group, and 103 eyes for the "Over 80" group. The spherical component of the subjective refraction, the cylindrical component, and the cylinder axis were recorded. Since little sex difference was noted, the data for men and for women were combined.*

So that the data may be subjected to statistical technics which require a normal or near normal curve, with-the-rule astigmatism was classified as a positive value and against-the-rule astigmatism as a negative value.

---

*An interesting sidelight to the present problem was a consideration of the distribution of higher degrees of astigmatism among men and women. Donders[2] stated: "Thus far I have met with many more cases of abnormal astigmatism in men than in women. I do not, however, feel justified in assuming that this is not partly accidental. This point must remain for future decision."

What Donders considered "abnormal" is not known, but in analyzing the data of the present sample, astigmatism of more than two diopters was considered as satisfying the requirement. Our results are presented below in tabular form. The numerator of the fraction is the number of eyes with astigmatism in excess of 2.00 D., while the denominator is the total number of eyes in this category. From these fractions, percentages are readily calculated.

Age Range	Men	Women
40-49	14/180 = 7.8%	12/220 = 5.5%
50-59	13/192 = 6.8%	10/208 = 4.8%
60-69	12/162 = 7.4%	12/238 = 5.0%
70-79	22/141 = 15.6%	16/162 = 9.9%
Total	61/675 = 9.0%	50/828 = 6.0%

It will be noted that for each age range, as well as for the total, there is more astigmatism of higher degree among the men than among the women. Furthermore, for the total there is about half again as much more among men than women. The statistical significance of the relationship (total) was tested by chi square and is found to achieve a level of between 0.05 and 0.01 (chi square = 4.75 for one degree of freedom). These data, then, substantiate Donder's casual observation.

For each group the mean and median cylindrical lens and the standard deviation were determined. All lenses were expressed as minus cylinders and those within 20° of 90° and 180° were considered as respectively "against-the-rule" and "with-the-rule." Cylinders whose axes were more than 20° from vertical or horizontal were omitted from this analysis. Also, cylindrical lenses in excess of 4.00 D. were omitted.*

The results are presented in Table 1. The number of cases reflects the number omitted as over 4.00 D. or as being oblique. In the first age group, for example, four of the original 200 eyes had astigmatism in excess of 4.00 D., and 32 had oblique cylindrical axes, leaving a total of 164 eyes for the analysis. The means, medians, and standard deviations were calculated in the customary manner. As stated earlier, the negative sign indicates against-the-rule astigmatism and the positive sign, with-the-rule astigmatism. All calculated parameters are expressed in diopters. The information contained in the table may be summarized as follows:

TABLE 1

Mean, Median and Standard Deviation of Astigmatism for Ages from 40 to over 80.

Age Group	Number	Mean	Median	Standard Deviation	Skewness
40-44	164	+0.27	+0.09	0.84	+0.64
45-49	166	—0.09	—0.08	0.74	—0.04
50-54	174	—0.12	—0.05	0.83	—0.25
55-59	168	—0.22	—0.20	0.91	—0.07
60-64	167	—0.27	—0.38	0.85	+0.39
65-69	170	—0.41	—0.43	0.89	+0.07
70-74	144	—0.43	—0.58	1.15	+0.38
75-79	107	—0.70	—0.63	0.98	—0.21
Over 80	93	—0.81	—0.91	0.93	+0.32

(1) With increasing age, both the mean and median exhibit a distinct trend toward against-the-rule astigmatism. Over the approximately 40 year age span studied, this change in the average seems to be very close to 1.00 D., or about a quarter diopter every 10 years. The change is more or less orderly, and by inspection of the plotted data we are unable to discern any age characterized by an accelerated trend toward against-the-rule astigmatism.

The standard errors of the means range from approximately 0.06 to 0.10. Therefore, while the change from one age group to the next

*Only 9 such cylindrical corrections were included in the sample and were distributed as follows:

Age 40-44 3 with-the-rule, 1 against-the-rule
Age 50-54 1 against-the-rule
Age 60-64 1 with-the-rule, 2 against-the-rule
Age 65-69 1 against-the-rule

may lack significance, the change over the 40 year period which exceeds the highest standard error by at least 10 times is quite statistically significant to a very low P value.

(2) Although the trend may not be apparent by inspection of the table, the standard deviation does rise slowly with increased age. The nine values for standard deviation were plotted against age, and these data were fitted mathematically to a straight line. The formula for this line is:

$$S = 0.5509 + 0.0057\ A$$

where S is the standard deviation and A is the age. The standard error of the slope is 0.00236, and the probability that a slope this different from zero could have occurred by chance is 0.05.* It is reasonable, therefore, to conclude that the standard deviation does increase with age, although by only a small amount. To be exact, the standard deviation increases by 0.23 D. in the 40 year span here investigated. This result should not be surprising since many measurements are characterized by greater variability in later years. It does, however, indicate that change in astigmatism is occurring.

(3) The skewness was calculated from the formula

$$\text{Skewness} = \frac{3\ (\text{Mean}—\text{Median})}{\text{Standard Deviation}}$$

While this is only an approximate measure, it will suffice in the present situation. By inspection of the table, it will be apparent that there is no trend with increasing age. The greatest degree of positive skew occurs in the youngest age group, while the greatest negative skewness occurs in the third from the youngest group. It seems reasonable to conclude that there is no change in skewness with increasing age, and in all instances the degree of skewness is probably a chance deviation from zero.

(4) The degree of kurtosis or peakedness for each distribution was not calculated. The data for three of these** were, however, tested for kurtosis by converting the cumulative frequency to probits and

*The author is indebted and expresses gratitude to Professor Frank W. Weymouth for the calculations of the standard error of the slope. Professor Weymouth also offers as a further demonstration of the increased standard deviation with age this analysis: The standard deviations for the first four age groups may each be compared with each of those for the older five age groups. Of these 20 comparisons, 18 show a larger standard deviation at the older age and only 2 the reverse. Of these 18, using the F ratio to compare variances, 5 show a P of 0.01 or less, 3 show a P of 0.05 to 0.02, while the remaining 10 fail to achieve significance at the 5 per cent level. However, if no difference in standard deviation existed, one would expect only half or 10 of the comparisons to be in this direction and no more than one to achieve 0.05 significance.

**Groups 45-49, 55-59, and 65-69.

plotting these values on a graph. By this method, a normal curve will result in a straight line, while significant deviation from normality will produce a curve. All three of the curves tested in this manner demonstrated leptokurtosis, and it seems reasonable to assume that all of the distributions in the present sample are characterized by some degree of leptokurtosis. This phenomenon may be attributed to either a piling up of cases toward the center or by a stretching out of one or both tails. Both conditions probably exist here.

The piling up in the center is in part due to the tendency of refractionists to under-correct astigmatism. We are well aware of a slight bias in this direction in our own clinical procedure, and faced with two possible cylindrical lenses each seeming to do almost equally well, we tend to accept the lower. This is particularly true in the lower powers and would lead to some small degree of leptokurtosis. The second cause is probably due to the fact that the higher degrees of astigmatism are truly abnormal and do not represent chance variation but rather some circumstance such as injury. For example, of the nine patients in this study with astigmatism in excess of 4.00 D., at least four attributed the condition to injury.

One of the frequency distributions† was further analyzed with the extreme cases omitted. The curve came much closer to normal, and sufficiently close so that the bias spoken of earlier could probably account for the remainder of the excess kurtosis. Although data are not here presented to completely substantiate our conclusions, we feel, after working with these data, that the distributions are essentially normal and that variations in skewness or kurtosis may be explained upon the bases already discussed.

Summarizing the data in Table 1, it appears that over the 40 year span here studied (from age 40 to age 80), the average astigmatic error changes from 0.25 D. with-the-rule to approximately 0.75 D. against-the-rule. The standard deviation over this same span of time increases from about 0.75 D. to about 1.00 D. Although a slight degree of leptokurtosis has been demonstrated, we feel that if clinical bias and the inclusion of abnormal or pathological or other anomalous causes could be controlled, the distribution curves would be essentially normal. On this basis, a pair of frequency distributions have been drawn which meet these conditions (See Figure 1):

(a) Both are normal curves.

(b) Both curves have approximately the same area.

†Age 55-59.

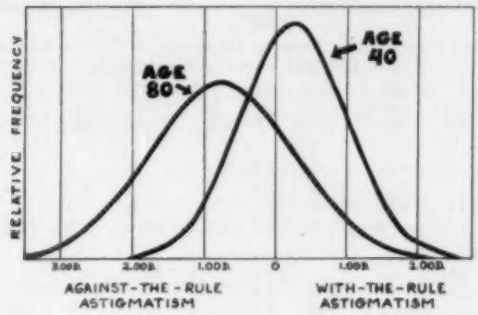


Fig. 1

(c) The curve for age 40 has a mean of +0.25 D. with-the-rule and a standard deviation of 0.75 D.

(d) The curve for the age 80 group has a mean of +0.75 D. against-the-rule and a standard deviation of 1.00 D.

While these curves are schematic, they contain all of the information which can be gleaned from the analysis in Table 1 and demonstrate graphically the shift in astigmatism which occurs in this period of life. It is apparent from the figure that all individuals do not change equally but rather that some individuals must change more than others, and this conclusion is worth emphasizing to clinicians. The clinician may expect some patients to exhibit little change over the 40 year period being discussed. On the other hand, he should not be surprised to find individuals who change as much as 1.50 to 2.00 D. in the direction of against-the-rule astigmatism, for the data indicate that such individuals must exist.

Another method of analysis of these data is to consider the frequency distributions for each age group. When these are considered with astigmatism treated in quarter diopter steps, the trend is difficult to determine, and for this reason the total range of astigmatism has been consolidated into seven steps. Percentages are used rather than number of cases because the last three age groups had fewer than 200 eyes (175, 128, and 103, respectively). The data presented in the above fashion appear in Table 2.

Studying the data in horizontal lines from top to bottom, we arrive at the following observations:

(1) For with-the-rule astigmatism of more than 1.00 D. (top two lines), we note little change in frequency with increased age. Although there seems to be a reduction in incidence of astigmatism of this

TABLE 2

Modified Frequency Distributions Showing Percentage of Eyes in Various Age Ranges with Different Types of Astigmatism.

	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	Over 80
With the Rule—									
Over 2.01 D.	6.0	1.5	1.5	3.0	1.5	1.5	4.6	1.6	1.0
1.01 to 2.00 D.	3.0	3.0	2.0	2.0	5.5	2.0	2.9	1.6	1.9
0.26 to 1.00 D	20.0	11.5	8.5	6.0	9.0	5.5	2.3	5.5	3.9
Zero ±0.25 D.	45.5	43.0	53.5	42.5	26.5	30.5	21.1	17.2	18.4
Against the Rule—									
0.26 to 1.00 D.	6.5	17.0	15.5	23.5	32.0	31.5	34.3	34.4	30.1
1.01 to 2.00 D.	1.5	6.0	3.5	5.5	9.0	11.5	13.7	19.5	30.1
Over 2.01 D.	1.5	1.0	3.0	2.0	2.0	3.0	3.4	3.9	4.9
*Oblique Astigmatism	16.0	17.0	12.5	16.0	15.0	14.5	17.7	16.4	9.7

*Oblique astigmatism includes cylinders which deviate from 90° or 180° by more than 20°.

type with age, it will be noted, for example, that at one of the upper age groups (70-74) there are 7.5 per cent showing with-the-rule astigmatism while in a lower age group (45-49), there was only 4.5 per cent. The figures in the 40-44 age group may be a sampling error. In using clinical data in a study like this, we must assume that something other than the variable being studied motivates the patient to visit the optometrist. In the present study, we assume that presbyopia and not astigmatism was such a factor. However, in the 40-44 age group we might have patients not yet requiring presbyopic lenses visiting the optometrist, and, hence, the number of higher astigats may be a reflection of this error. Whatever the case, no systematic and marked decline in with-the-rule astigmatism of more than 1.00 D. is observed with increasing age.

(2) In the case of the lower degrees of with-the-rule astigmatism, there seems to be a decided trend, even if the figure in the 40-44 age group is omitted. There seems to be a clear decrease in the incidence of lower degrees of with-the-rule astigmatism with increasing age.

(3) The number of patients with no astigmatism, or with only 0.25 D. of astigmatism, also declines markedly with age. Although it is not possible to be certain, the decline in this group seems to become most marked at about the sixtieth year, and then continues to decline steadily to the age of 75 at least.

(4) Against-the-rule astigmatism of low degree (up to 1.00 D.) increases steadily at least to the age of 65, after which time there seems to be little change.

(5) Against-the-rule astigmatism of between 1.00 and 2.00 D.

does not increase markedly until the sixtieth year, but after this it rises rapidly and in a systematic fashion.

(6) Against-the-rule astigmatism of more than 2.00 D. increases slowly, but in a more or less systematic fashion. The numbers are too small to determine if there is a steeper rise at any age group than at any other.

(7) The percentage of patients with oblique astigmatism does not appear to vary with age, only one figure, that at the oldest age group differing markedly from the others. Since this lone abnormal value could by chance (95% confidence limits) be as high as 18.0 per cent, it seems reasonable to conclude no difference.

If the three categories of with-the-rule astigmatism are grouped and if the same thing is done with the three categories of against-the-rule astigmatism, the trend will be shown quite concisely. This has been done and these data are presented in Table 3. While such a form of

TABLE 3

Percentages of Eyes Having With-the-Rule and Against-the-Rule Astigmatism and No Astigmatism.*

	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	Over 80
With-the-Rule Astigmatism	29.0	16.0	12.0	11.0	16.0	9.0	9.8	8.7	6.8
Zero ±0.25 D.	45.5	43.0	53.5	42.5	26.5	30.5	21.1	17.2	18.4
Against-the-Rule Astigmatism	9.5	23.0	22.0	31.0	43.0	46.0	51.4	57.8	65.1

*Columns do not add up to 100% because oblique cylinders (See Table 2) are omitted.

analysis may obscure some of the changes, particularly any acceleration of rate of change at a particular age, it demonstrates without any doubt the marked increase in against-the-rule astigmatism and the decrease in with-the-rule astigmatism and in no astigmatism.

Conclusions: The data presented in this study demonstrate a marked trend toward against-the-rule astigmatism with increasing age. This is in agreement with the findings of most investigators. How then does this fit in with the data of Kratz and Walton? We believe that there is no conflict. Kratz and Walton studied the same patients over a period of ten to twenty years and found that 60.2 per cent changed 0.25 D. or less. This means, however, that 40 per cent changed more than this amount. In the present study the average degree of change is only 0.25 D. per ten years. It is only when a 40 year age span is considered that the change is seen to reach significant proportions. Also, Kratz and Walton studied all age groups, while the present study is

confined to the older patients. It is very possible that between the ages of 20 and 40 little change occurs, and this would tend to obscure the change of the older patients in the Kratz and Walton study. It is our feeling, therefore, that the findings of Kratz and Walton are not inconsistent with those of other investigators, but rather that the change in astigmatism is small but nonetheless real and significant over a greater time interval.

No attempt has been made here to ascertain the cause of this change in astigmatism. Most authors attribute it to changes in the crystalline lens, and this seems to be the best theory at present. Nothing in the present study would confirm or deny this theory. In a former study[1] we demonstrated that in this same age span there was a real and marked change in spherical refraction in the direction of hypermetropia. This, too, is usually attributed to changes in the crystalline lens. Combining the results of the two studies, it would seem that the present best guess as to what changes occur between ages 40 and 80 is this: The crystalline lens, which as we know continues to grow throughout life, grows in such a manner as to create more hypermetropia, and this more in the vertical meridian than in the horizontal.

In this former study it was shown that the equivalent sphere changed a total of approximately 1.00 D. toward increased hypermetropia over this age range. The present study shows a change of 1.00 D. of astigmatism. Combining these, it would appear that on an average the crystalline lens must become 0.50 D. more hypermetropic in the horizontal meridian and 1.50 D. more hypermetropic in the vertical meridian over a 40 year period. This would be an average change of $+0.12 \supset +0.25 \times 180$ per ten years. This change, although small, seems to be real. It must be stressed again, however, that this average change is not to be expected in all patients—some change more and some less. The change toward myopia, found in older groups (past age 60), and preceding cataract development has not been considered in these calculations.

In the preceding paper it was pointed out that the findings could be clinically useful in the examination of old patients. The present data may be given the same use. With an older patient incapable of many rapid judgments, it might be well to consider the earlier refractive records, guess at the change which might take place, and try this change or variations of it over and over again slowly. The addition, for example, of $+0.25 \supset +0.50$ axis 180° might well be tried over an old prescription for a simple comparison. Furthermore, inspection of the graph indicates that some patients change more markedly, and these

are probably those already having the greatest amount of astigmatism. Thus, the clinician will be guided by both the nature of the prescription and the "average change."

A final study in the present series is contemplated, and that is to determine whether there is any relationship between the spherical and cylindrical corrections and whether this relationship is affected by age. It has been claimed that higher astigmatic errors are found along with higher spherical errors, and this hypothesis bears further investigation, especially in so far as the effect which age may have upon it. Such a study will be undertaken in the near future upon similar data to those presented in these first two papers.

REFERENCES

1. Hirsch, Monroe J., Changes in refractive state after the age of forty-five, Am. J. Optom. and Arch. Am. Acad. Optom., 35 (5): 229-237,1958.
2. Donders, F. C., On the Anomalies of Accommodation and Refraction of the Eye. London, The New Sydenham Society, 1864, p. 513.
3. Helmholtz's Treatise on Physiological Optics (translated from the third German edition), edited by James P. C. Southall. Vol. 1. Rochester, N. Y., Optical Society of America, 1924, p. 382.
4. Sheard, Charles, Physiological Optics. Chicago, Ill., Cleveland Press, 1918, p. 146.
5. Duke-Elder, W. Stewart, Text-book of Ophthalmology, Vol. 4. St. Louis, Mo., C. V. Mosby Company, 1949, p. 4291.
6. Kratz, J. Donald and William G. Walton, Jr., A modification of Javal's rule for the correction of astigmatism, Am. J. Optom. and Arch. Am. Acad. Optom., 26 (7): 295-306, 1949.
7. Walton, William G., Jr., Refractive changes in the eye over a period of years, Am. J. Optom. and Arch. Am. Acad. Optom., 27 (6): 267-286, 1950.

ANNOUNCEMENT

WORLD HEALTH TRENDS AND OPTOMETRY

A symposium on the Implications of World Health Trends as Related to Optometric Care is scheduled by the Optometric Center of New York, September 23, 1959, at 8:30 P. M. The meeting will be held in the Warren R. Austin Memorial Auditorium, United Nations Plaza at East 46th Street, New York City. The meeting is open to all optometrists without cost. The speakers and their subjects will be:

Mr. Harry Freeman, Executive Member of the Council of the British Optical Association (London). *Recent Developments in European Optometry and Trends in British Optometry During Ten Years Under the British National Health Service.*

Mr. Edward Higgins, Managing Director, Canadian Optometric Association (Toronto). *Trends Toward the Development of a Canadian National Health Service and Their Effect on Optometric Care.*

REFERRALS FROM VISUAL SCREENING OF SCHOOL CHILDREN*

Vernon Ryan†
Pennsylvania State College of Optometry
Philadelphia, Pennsylvania

An experimental visual screening program is usually designed to investigate the correctness of referrals made by one or more visual screening procedures. The method generally employed is to submit a large group of school children to visual screening and as far as possible follow up with the full clinical ophthalmic examination of the same children within a reasonably short period of time. On the basis of results obtained at the clinical examination each referral is designated "correct" or "incorrect." Thus, if treatment such as the prescribing of medication, orthoptics, or spectacles is found to be necessary then the visual screening referral is said to be "correct." If no such treatment is prescribed then the referral is "incorrect." On this basis as many as 50 per cent or more of the children referred by some experimental visual screening procedures have not shown the need for any treatment even though they failed the screening tests.

Such results as the above are certainly disappointing and they reflect poorly upon the visual screening procedures that were used. It is possible, however, that a serious injustice is done to the screening procedures unless the "incorrect" referrals so designated by clinicians are fully considered and properly analysed. The writer, therefore, here attempts to clarify the situation not by analysing all referrals simply on the basis of "correct" or "incorrect" but rather under three groupings as follows:

1. Correct referrals.
2. Justified referrals.
3. Erroneous referrals.

Correct referrals are those which on clinical examination are found to need refractive, orthoptic, or other treatment.

Justified referrals are those patients who cannot meet the standards set up for the screening program but, in the opinion of the clinician, cannot benefit by refractive, orthoptic, or other treatment.

---

*Read before the annual meeting of the American Academy of Optometry, Chicago, Illinois, December 9, 1957. For publication in the August, 1959, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist. Member of faculty. Fellow, American Academy of Optometry.

Erroneous referrals are those which should not have been recommended for clinical examination on the basis of the standards set up for the screening program.

Much of the confusion existing in the minds of laymen arises from our custom of considering referrals simply as "correct" or "incorrect." It is the aim here to show that most of the referrals usually classified as "incorrect" belong to the grouping of "justified" referrals and not the grouping of "erroneous" referrals.

CORRECT REFERRALS

It is not surprising to learn that there is an ever increasing tendency among parents, teachers, and school authorities to demand a straight answer from the profession on several questions. Uppermost in the minds of many interested people is this question: "Upon what basis will the profession validate the referrals from visual screening procedures?" No doubt, there is a desire to have optometrists state precisely and quantitatively the clinical visual findings which decide the correctness or incorrectness of referrals.

In any group of children there is an indeterminate number who can benefit by eye care, as well as a number who exemplify the borderline cases. The term "eye care" must here be taken to mean not eye examination and refraction alone, which of course should be given to everyone periodically, but, rather, the treatment prescribed after such examination.

When an optometrist prescribes lenses or other treatment to aid vision, he is, in the vast majority of cases, correct in the belief that such treatment is justified. But, he has no sure criteria that will guide him in knowing who will benefit by a particular treatment. Thus, it is impossible to say with certainty whether or not an asymptomatic child should wear a spectacle correction for a certain degree of hypermetropia or for a low degree of astigmia. If certain symptoms are evident, a prescription can be given with a high degree of confidence that it is justified, but even in such a case there is no absolute certainty. Optometrists are fallible and although they judge the need for eye care objectively they utilize subjective signs and tests, and thus must necessarily make occasional errors. It would be nice if we could tell just what visual and other physiological and psychological results would occur when we write a prescription to correct 1.00 diopter of hypermetropia at any particular age. In the opinion of some, such a prescription may prevent juvenile delinquency. It will certainly give ocular comfort to some patients, and in others such a correction may lessen the likelihood of serious neurological disturbances. Of course, some

patients will not benefit at all, in spite of one or more diopters of refractive error which have been wholly or partially corrected by the lenses.

It is, therefore, unfortunate that the desire exists among laymen and even some of the eye men to have the ophthalmic profession state precisely just what clinical findings indicate the need for treatment. If it were possible to do this in simple terms, then those doing the screening would know in advance which children need treatment and, theoretically at least, in future screening programs there would be no incorrect referrals. However, optometrists cannot state in simple terms the basis upon which referrals will be validated. It all depends upon the individual child, and every case must be decided upon its own merits. Most optometrists believe that muscle imbalance means nothing at all except in relation to that part of the visual function serving as the reserve. Thus, six prism diopters of esophoria may be a handicap to one child and not to another where the prism divergence power is adequate to cope with the imbalance. A screening procedure may be designed to fail any child having more than six prism diopters of esophoria. If, in such a case, the excess of esophoria is clinically confirmed, it does not follow that the referral must be validated by the prescribing of treatment. The referral will not be validated if, in the opinion of the optometrist, the child's reserves render treatment unnecessary. It may be said, however, that the referral is justified. Scobee uses the term "theoretical referral" in respect to such a case. It is unfortunate that justified referrals are classed along with "incorrect referrals."

The situation is further confused because of differences of opinion regarding other visual functions. For instance, some doctors[1] believe that 20/30 vision is adequate and imposes no handicap upon a child, or even 20/40 in the case of younger children. Other doctors say that such acuity standards are inadequate. Differences of opinion such as this makes it impossible to state in simple terms the basis upon which the referrals from visual screening will be validated.

Some cases of subnormal vision are developmental in origin and may be quite unassociated with refractive error (i.e., congenital amblyopia). If such patients are subjected to visual screening procedures they will be referred and found to require no treatment. These may be regarded by parents as needless referrals. When a refractive error is associated with a vision defect, then the referral becomes a correct referral if in the opinion of the optometrist the correction materially benefits the child. However, some visual handicap may remain, although the best correction is prescribed, and the child may fail a subsequent screening

test. If the child is again referred, then since no further improvement in vision is possible, the second referral will be classed as incorrect. Such possibilities relating to visual acuity, added to the fact that doctors disagree as to what acuities are adequate, explain a large number of needless referrals. Most doctors insist on the generalization that if treatment is given, the referral is correct, and if no treatment is necessary then the referral is incorrect. Beyond such a statement, the doctors refuse to go.

In many cases only time can validate a "validation." The opinion of the optometrist as to whether treatment is, or it not, necessary is sometimes upheld by subsequent events. It is not possible to state with certainty, therefore, what subnormal visual acuities require correction by means of spectacles, what refractive errors justify a prescription for lenses, what muscle imbalances need orthoptic or other treatment, and the like. If such statements were possible, then simple answers could be given to those who ask the question, "What do optometrists consider a correct referral?"

JUSTIFIED REFERRALS

When referral standards are set up for visual screening procedures, their purpose is to screen out those children most likely to benefit from full clinical examination; and that is all. If the cut-off scores for muscle imbalance are set at four prism diopters of esophoria and six prism diopters of exophoria, no guarantee can be given that a referral because of a greater amount of imbalance will be validated. It is gratifying on the one hand when the failing referral finding is clinically confirmed, and regrettable on the other hand when the referral may have to be thought of as incorrect in the sense that no treatment whatever is required. There is some satisfaction in knowing that the referral finding is clinically upheld, even though no treatment is indicated, for such a referral is justified even though not validated. The problem is to convince parents who have paid for a clinical examination that a justified referral did not put them to an unjustified expense. From the parents' point of view, all referrals which do not call for spectacles or other treatment are incorrect referrals. At any rate, such is the impression with which they are left as the result of improper handling by many optometrists. Talking about the justification for the child having been sent for clinical examination does not easily satisfy the parents. It is hardly human for parents to be satisfied with such an outcome; strangely enough having paid for a clinical examination many parents are happier if the child really does need spectacles.

Two things must be appreciated about the over-referral group.

Firstly, vision screening programs are not so bad as they may be judged to be superficially with respect to incorrect referrals, because the group of incorrect referrals contains a large proportion of justified referrals as distinct from out-and-out erroneous referrals. Secondly, something has to be done about the handling of the justified referrals, both in the interests of the child and the satisfaction of the parents. It is possible that a good deal of harm has been done to screening programs and to the visual welfare of children because of the honest optometrist donning a "halo" and proudly announcing that the child just examined requires neither spectacles nor any other treatment, collecting his fee, and leaving the matter right there in the belief that he has delighted the parents and fulfilled his obligations. I do not presume to have the answers to questions naturally arising out of the above statements. For the present time I must feel satisfied in pin-pointing what I believe to be the biggest outstanding problem in school visual screening programs, namely, the problem of the justified referrals. Sometimes, even simple advice concerning visual habits and hygiene in relation to the child's visual peculiarity for which no spectacles are required, together with a few words of praise for the school vision care which directed attention to the defect, might completely eliminate the impression of wrong referral which would otherwise remain with the parents. In some cases of justified over-referral there should be watchfulness on the part of both parents and teachers in case signs and symptoms of ocular fatigue develop later on.

ERRONEOUS REFERRALS

Erroneous referrals are the inexcusable over-referrals as distinct from the justified over-referrals. The cause of the failure at the screening examination will not be borne out at the clinical examination or, if the clinical examination does verify the defect causing the failure, reasons can still be advanced to show that the referral was unjustified. Many such erroneous referrals have resulted from what is now being appreciated as unnecessary, namely, the screening of children who wear spectacles. Many such children continue to have visual defects in spite of the very best professional care, and in any case it is obvious that these children are under professional care and this fact disqualifies them from visual screening except in diagnostic reading examininations. The Danbury Study[2] showed conclusively that if children already under care are subjected to repeated visual screening examinations, many such children will be needlessly referred. Such referrals cannot be regarded as justified and certainly cannot be validated. In these cases it was already known by clinicians that the visual handicaps remained. If anything further could have been done it would have been done. At least

such must be assumed. Needless referrals of this type are truly erroneous. Obviously the over-referral group can be much reduced by the proper handling of those who wear spectacles. The question now arises as to what other examples can be cited of erroneous referral.

Many totally erroneous referrals arise because children fail to perform to the best of their ability. This is the reason why failures should be given a second chance at the screening procedure before being referred. Such erroneous referrals as these comprise a rather small category compared to the number making up the group of justified referrals, especially when the re-checking is done before referral. A skilled examiner can minimize such erroneous referrals by putting the children at ease and by making certain that they fully understand what is expected of them in the various steps of the screening procedure. In spite of all due care, however, it may be impossible to recognize cases where emotional or other causes account for failure to give evidence of the required acuity, or of normal muscle balance, fusion, stereopsis, etc., when in reality the tests can be passed, as later examination will show. Thus, it is sometimes found that a child fails a screening test with respect to visual acuity and then upon clinical examination displays a Snellen acuity such that the screening test should have been passed. So too, the optometrist may find a lower muscle imbalance than the requirement for passing the screening procedure on a child who has recently failed the test, even when using the same kind of heterophoria test, but this is sometimes due to normal variations and even to the influence of volition. In fairness to vision screening examiners, it should be pointed out that lapses of ability and understanding on the part of children occur not only in the screening rooms but also in doctors' offices. The very best optometrist upon occasion finds it impossible to state accurately a child's visual acuity, muscle balance, or other skill at a single examination, and it must be further stated that this often depends upon the optometrists emotional situation rather than that of the child. How important it is, therefore, for screening examiners to realize that they themselves enter into the screening procedure, and that they themselves may be and may not be responsible for erroneous referrals.

It may be worthwhile to remind ourselves that the term "muscle imbalance" as applied to a phoria may cause much misunderstanding. For instance, eight prism diopters or more of distance esophoria which would cause referral is in a sense not an imbalance at all if the prism divergence power of the eyes is adequate to cope with the phoria. In fact, the eyes may be well balanced in spite of the so-called imbalance. All that can be said about the phoria finding is that under the test con-

ditions which suspend fusion, the distribution of basic tonic innervation to the extra-ocular muscles is such as to give the eyes a resting position involving eight prism diopters of convergence and that, since this amount is considerable, it would be well to examine the reserve function that will have to cope with the convergence tendency when fusion is restored. If the optometrist finds the reserve to be inadequate, the referral is correct. If the reserve is adequate, the case is a justified over-referral. If the optometrist does not find a sufficient amount of phoria to account for failure at the screening examination, then the referral is erroneous. The justified referrals play a large part in blackening the reputation of screening programs for they far out-number the erroneous referrals.

It is also highly questionable whether children should be referred for exophoria at near, because the term is only an indication of the amount of fusional convergence used in near vision to complement the accommodation-convergence. Developmentally, fusional convergence precedes accommodation-convergence, and since most people have, relatively speaking, an abundance of the former, it is doubtful whether the latter plays an important role. But in any case, while it is undeniable that exophoria at near represents a demand that must be met by a fusional reserve, the likelihood of the reserve not being adequate is so slight as to warrant the measuring of the reserve not worthwhile unless the exophoria is about 10 prism diopters or more, for a test distance of 16 inches.

Erroneous referrals may result from the inclusion in vision screening procedures of tests which lack adequate reliability and validity. This is controversial ground, and it must be made clear that there is no desire to belittle such visual skills as fusion and stereopsis so much as to question the tests used to investigate these skills. When the eyes are used under ordinary conditions, fusion extends over most of the combined visual fields, certainly over a total area subtending an angle at the eyes of about 120 degrees in the horizontal meridian. There is a considerable difference between fusion under those conditions and the fusional requirement of an instrument in which one sees four small targets as three targets when two are fused. Other factors such as retinal rivalry enter into the perception of test targets such as these. Moreover, if the subject looks at one of the targets not requiring fusion, then the parts which should be fused are seen extra-foveally where vision is not so good or fusion so certain. Volition often upsets a test for fusion, for not infrequently even a young child will learn in an instant that three or four targets can be seen at will. Tests for stereopsis performed quickly

upon a subject never previously having played with a stereoscope are of all sub-tests likely to be most responsible for erroneous referrals. Many people, even adults, at first display no evidence at all of stereopsis, but can be shown within 10 minutes or so to have 100 per cent depth perception. Once they have got the idea of tridimensional vision in an instrument, they perform perfectly, whereas at a first test such patients may appear to be totally lacking in this skill. There is no doubt then that some erroneous referrals arise because of the need for better tests, or for a better understanding of these tests on the part of both children and examiners.

In summarizing the causes of erroneous referrals, we can see that they arise mainly in three ways. They may be due to a misconception as to who should be given the screening tests; they may be due to failure on the part of the children who are screened to give normal performance, or they may be due to lack of reliability and validity, or significance of the sub-tests. Often a combination of factors causes erroneous referrals. Whatever the cause, the percentage of erroneous referrals should be a comparatively small one in the total group of over-referrals. The problem of the erroneous referrals is a comparatively small one as compared to that of the justifiable referrals.

ANALYSIS OF OVER-REFERRALS

1. *Justified Referrals.*

These are what Scobee terms "theoretical referrals." They account for the majority of the over-referrals. Clinical tests show that the children in this group properly failed the screening procedure. They include:

(a) Children having uncorrectible substandard acuity of vision resulting from congenital amblyopia, congenital cataract, corneal opacities, etc.

(b) Children with excessive heterophoria, where the child is found upon examination of the function which copes with the phoria to have adequate reserves and, therefore, to have eyes which are well balanced. The term "muscle imbalance," as applied to heterophoria in general, is perhaps unfortunate.

2. *Erroneous Referrals.* (True incorrect referrals)

(a) Children already under professional care.

(b) Children failing to perform up to their normal standards.

(c) Lack of reliability and significance of sub-tests.

(d) Needless referrals on the basis of judgment with respect to signs and symptoms that may indicate the need for professional care.

In the above analysis it is stated that the group of justified referrals

accounts for the majority of the total group of over-referrals. This belief is based upon statistical evidence from the St. Louis study[3] which used the results of clinical examination to show how many correct referrals and how many justified referrals there should be.

TABLE 1

RESULTS OF COMPLETE EYE EXAMINATIONS ON 1,215 CHILDREN IN THE ST. LOUIS PUBLIC SCHOOL SYSTEM

(After Scobee)

On the basis of clinical findings only, the eye doctor anticipates the following:

Reason for referral	Correct† Referrals		Justified† Referrals		Total Correct and Justified Referrals	
Asthenopic symptoms only	25	(2.0)*	63	(5.2)	88	(7.2)
Asthenopic Symptoms plus subnormal V.A.	60	(5.0)	44	(3.6)	104	(8.6)
Subnormal visual acuity	109	(8.9)	69	(5.7)	178	(14.6)
Unequal normal visual acuity	23	(1.9)	46	(3.8)	69	(5.7)
Heterophoria and Heterotropia	53	(4.4)	22	(1.8)	75	(6.2)
Refractive error	34	(2.7)	2	(0.2)	36	(2.9)
Ocular inflammation	8	(0.6)	1	(0.1)	9	(0.7)
Miscellaneous	4	(0.3)	2	(0.2)	6	(0.5)
Total	316	(25.8)	249	(20.6)	565	(46.4)

†Scobee used the term "actual" in place of "correct," and the term "theoretical" in place of "justified."

*Figures in parentheses are percentages of the total sample of 1,215 children.

Table 1 above does *not* show the results of a visual screening procedure as "Reason for referral" might suggest. It is best understood by thinking of full clinical examination preceding any visual screening. The results of the clinical examination are here used to show the exact number of children who should be referred at a visual screening examination on the assumption that the screening results can correlate perfectly with the clinical data. In other words, Table 1 tells us the number of children who should be referred, whether or not the screening is actually performed. The various reasons for which the referrals might be made are also given together with the respective numbers of children in each category.

The details given in Table 1 are relatively unimportant. What *is* important is the fact that from the figures given in this table by Scobee it can be seen how very sizeable is the group of justified referrals relative to the group of correct referrals. A screening procedure used at St. Louis could have referred 46.4 per cent of the total population of 1,215 children exclusive of erroneous referrals of which the table given above takes no account. Of this 46.4 per cent, over one-half (25.8 per cent

of the population) would be correct referrals, while very nearly as many (20.6 per cent of the population) would be justified referrals. Scobee's table yields the mathematical ratio that for every 100 correct referrals from an adequate visual screening procedure having high validity, 78 justified referrals should be forthcoming. Obviously then, in any group of "over-referrals" the justified referrals must greatly outnumber the erroneous referrals. If for every five correct referrals there can be about four justified referrals, there just is not room enough for many erroneous referrals in any well conducted visual screening procedure having a total referral rate as high as about 46 per cent of the population.

In the light of what has been said above, it is well to examine the St. Louis[4] percentage table showing correct and incorrect referrals. Only results for the sixth grade children are considered here. (Table 2.)

TABLE 2
ST. LOUIS STUDY
Sixth Grade
Percentage Table

		Per Cent Referred	
		Correctly	Incorrectly
Clinical Examination		31	
Ortho-Rater	Nurse	25	32
	Technician	24	29
Sight Screener	Nurse	23	31
	Technician	24	23
Telebinocular—Study standard	Nurse	24	33
	Technician	23	27
Telebinocular—Mfr's standard	Nurse	23	38
	Technician	24	33
Snellen high standard, Near Vision high std., & Teacher Judgment	Nurse & Teacher	23	28
Snellen high standard & Judgment	Teacher	21	24
Massachusetts Vision Test	Technician	20	11
	Nurse	18	12
Snellen high std., & Near Vision high std.	Nurse & Teacher	20	15
	Technician	18	8
Snellen high standard	Nurse	14	6
	Teacher	15	6
	Technician	14	2
Judgment	Teacher	13	19
Snellen low standard	Teacher	8	2
	Technician	7	1

In the period of nearly ten years since the St. Louis study, the above table has been the cause of much disappointment in that nearly all the screening procedures show a high rate of over-referral. It is the aim here to make some clarification of the over-referrals and defend a number of the procedures that were used. If when examining Table 2 one realizes that for every five correct referrals there ought to be, according to Scobee, four justified referrals included with the "incorrect," then

the second column of percentages is certainly no disgrace to the procedures used. It is the caption for the second column that is unfair, for "incorrect" implies erroneous, and yet only a small proportion of the referrals are truly erroneous. All in all, the visual screening procedures can do an excellent job in properly referring those who fail to comply with certain set visual requirements. At least let credit be given for that achievement, for "properly referring" is all that can be expected of machines. It is not the fault of machines and procedures utilizing them that the data so obtained do not correlate well with minds exercising judgment to act or not to act upon the data which the machines supply, especially when it is remembered that the minds have the advantage of being able to perform unlimited tests to aid experience and intelligence. Table 2 can, furthermore, be seen to reflect even more credit upon screening instruments when it is remembered that the small proportion of erroneous referrals included with the justified referrals as incorrect, could be still further reduced if the referral of children who wear spectacles were eliminated altogether and other failures were rechecked before referral.

CORRELATION WITH CLINICAL DATA AS COMPARED TO CORRELATION WITH CLINICAL JUDGMENT.

It has already been seen that according to Scobee[3] the visual screening procedures used at St. Louis could have been expected to yield about 78 justified referrals along with every 100 correct referrals on the basis of the referral standards and validation criteria there used. In a previous paper,[5] a table was presented in which a number of the St. Louis screening procedures are rated in terms of the point correlation coefficients with respect to clinical judgment. The data are reproduced here in Table 3 along with an additional column showing correlation with clinical data. To put it very simply, an allowance is here made for justified referrals which largely account for the very low correlations with clinical judgment. Having made such an allowance it was found that in most cases there is decidedly higher correlation. The method by which this has been done is given in the Appendix where it is seen that the number of over-referrals has been reduced in proportion to the justified referrals that can be expected, and the number of correct referrals correspondingly increased. In this way the point correlation coefficients with the St. Louis clinical *data* become known approximately.

It would be expected that every procedure correlates better with clinical data than with clinical judgment, and it may come as a surprise to note that the reverse is true in two cases shown in Table 3. The Snellen high standard procedure and, particularly, the Snellen low

TABLE 3

POINT CORRELATION COEFFICIENTS

St. Louis 6th Grade

Screening Procedure		Clinical Judgment	Clinical Data*
Snellen high standard	Technician	+0.52	+0.40
Snellen high std. + Near Vision high std.	Technician	+0.49	+0.53
Snellen high std. + Near Vision high std.	Nurse & Teacher	+0.41	+0.65
Massachusetts Vision Test	Technician	+0.48	+0.59
Sight-Screener	Technician	+0.40	+0.76
Snellen low standard	Technician	+0.38	+0.26
Ortho-Rater	Nurse	+0.33	+0.54
Snellen high std. + Near Vision high std. + Judgment	Teacher	+0.31	+0.52
Telebinocular . . . Manufacturer's std.	Technician	+0.27	+0.46
Telebinocular . . . Study standard	Technician	+0.33	+0.55

*Author's computations on the basis of the expected 78 justified referrals along with every 100 correct referrals. "Incorrect" referrals are proportionately reduced and "Correct" referrals are correspondingly increased. (See appendix.)

standard procedure show decidedly poorer correlation with clinical data then with clinical judgment. The Snellen procedures so thoroughly under-refer as to miss not only many cases of significant visual defect but also miss the majority of the justified referrals demanded by St. Louis clinical standards for referral. This has to be so because all the reasons for referral listed in Table 1, except one, are ignored by those who use only the Snellen procedure for visual screening. In contrast to this, the multiple test procedures have a referral capacity that is sufficiently large to include the proper quota of justified referrals, thereby making for a better overall correlation with clinical data.

While it is hardly fitting here to include all the computations, it should be pointed out that the data reveal interesting sidelights on the various procedures. In particular it is seen that the Massachusetts Vision Test (M.V.T.) refers cases a little too cautiously. It refers too few children for us to be able to include with them all the justified referrals that may be reasonably expected. At least this was so at St. Louis. The M.V.T. has, like the Snellen high standard procedure, fairly good correlation with clinical judgment, but while Snellen correlation with clinical data goes down, Massachusetts correlation with clinical data goes up. I think that there is a clear indication that the M.V.T. would correlate still better with judgment if the total referral rate were increased by the addition of a supplementary test. A study of the above tables suggests that if a near vision acuity test were used in conjunction with the M.V.T. (and the American Optical version of the test is readily adaptable to this purpose) there would be better correlation both with clinical judgment and clinical data.

It may be said that it is absurd even to consider correlation with clinical data when correlation with clinical judgment as to the need for treatment is all that matters. The fact is, however, that in considering correlation with clinical data we are able to see the procedures in a new light. This is just another way of observing why, for instance, the Snellen test which has perhaps the highest correlation with clinical judgment also has very poor success in finding the needed referrals (See Tables 2 and 3). Whatever criticism may be forthcoming concerning the correlation with clinical data, at least such consideration enables us to see one thing very clearly. If multiple-test batteries are used strictly according to instructions for the visual screening of children not already under professional care, there will be very few improper referrals. There will, of course, be a certain proportion of referrals not requiring treatment but very properly sent for examination. These referrals we may think of as justified referrals, and they are no reflection on the reliability and validity of the instruments used. A machine cannot be expected to correlate well with a mind unless more of the mind goes into the design of the machine than is the case at the present time. Thus, a machine measures a heterophoria and an optometrist measures other related visual functions to see if the eyes are truly balanced or truly imbalanced. Maybe an optometrist can devise a screening subtest that rather than merely measuring a heterophoria would at the same time indicate whether or not the eyes can stay straight without fatigue when used under normal conditions. Only such a test can be expected to yield results which will correlate well with those obtained by the mind. In fact, such a test might surpass the mind, for the test would eliminate objective judgment and, itself, indicate that treatment is or is not needed. Happily, it is not expected that the machine would eliminate the examiner; he will still be needed for the providing of treatment. Maybe the logic of all this indicates the need of better tests of fusion rather than better tests of muscle imbalance.

THE DANBURY STUDY AND ERRONEOUS REFERRALS.

More light is shed on the incidence of erroneous referrals by Leverett[6] in his report on The Danbury School Vision Health Study. The new Massachusetts School Vision Test (American Optical Company) was used in 1952-53 at Danbury, Connecticut, on a very large group of children. The study showed that 72 per cent of the referrals were "correct" and 28 per cent were "incorrect." There is, however, strong evidence to support the contention that only five per cent of the referrals were truly erroneous and that there were 23 per cent justified referrals. In view of all that has been said it must be admitted that the

Massachusetts Vision Test as used at Danbury yielded excellent results in the qualitative sense.

SUMMARY AND CONCLUSIONS.

It is not practicable for optometrists to state precisely in quantitative terms the clinical visual findings that should be used as a basis for deciding the correctness or incorrectness of child referrals from visual screening programs. Many factors enter into the validation of referrals.

Analysis of the performance of visual screening procedures simply in terms of "correct" and "incorrect" referrals is in some respects unfair. The majority of the referrals in the "incorrect" group are justified referrals, i.e., referrals properly made at the screening examination but found upon clinical examination not to require treatment. Only a small minority in the incorrect group are erroneous referrals.

The multiple test batteries show much better correlation with clinical data than with clinical judgment. This is because, as Scobee pointed out, for every five correct referrals there should be about four theoretical (justified) referrals if the screening procedure is adequate and has high reliability and validity. If a procedure refers nearly as many children not requiring immediate treatment as those who do require treatment then obviously there are not likely to be many children who are being erroneously referred.

The biggest outstanding problem in the visual screening of school children is that of the justified referrals.

The Snellen Test has a poorer coefficient of correlation with clinical data than with clinical judgment. This results from the inadequate referral rate, especially in the case of the low standard Snellen procedure.

The Massachusetts Vision Test, which has fairly good correlation with clinical judgment, has even better correlation with clinical data. There may, however, be a need to increase the referral rate a little for this procedure. There are indications that this could best be achieved by the use of a supplementary visual acuity test at near.

APPENDIX

POINT CORRELATION COEFFICIENT

Ortho-Rater (Nurse). 6th Grade. St. Louis

(a) Correlation with clinical judgment as to need for treatment.

	REFERRALS		NON-REFERRALS		TOTAL	
Clinical Judgment		190		419	609	
Visual Screening—						
Correct	155		Under-referrals	35		
Incorrect	196		True non-referrals	223		
		351		258	609	

$$\text{Coef. of Correl. with Judgment} = \frac{(155 \times 223) - (196 \times 35)}{\sqrt{190 \times 419 \times 258 \times 351}} = 0.33$$

According to Scobee we may reasonably expect 78 theoretical (justified) referrals for every 100 correct referrals. Therefore, in order to arrive at an appoximate correlation with clinical data it is necessary for us to determine the number of expected justified referrals as follows:

There are 1.90 (hundreds) requiring treatment: these are the clinicians' "correct referrals." Along with these should be $1.90 \times 78 = 148$ justified referrals. On the basis of clinical data alone, therefore, the clinician acknowledges that $190 + 148$ children should be referred as a result of the screening examination. A total of 338 children should be referred if there is to be good correlation with clinical data, and this number of referrals for "clinical data" is used in part (b) below.

In the same manner it is determined that for the screening procedure in which 155 children were correctly referred, there should be $1.55 \times 78 = 121$ justified referrals. Therefore, in approximately correlating with clinical data, the number of children to be regarded correctly referred by the screening procedure is to be increased by 121 and the non-referrals decreased by the same number.

(b) Correlation with clinical data as meriting referral.

Number of children to be regarded as correctly referred $= 155 + 121 = 276$.
Number of children to be regarded as wrongly referred $= 196 - 121 = 75$.

	REFERRALS		NON-REFERRALS		TOTAL
Clinical Data	338			271	609
Visual Screening—					
Correct	276	Under-referrals	62		
Erroneous	75	True non-referrals	196		
	351			258	609

$$\text{Approx. Coef. of Correl. with clinical data} = \frac{(276 \times 196) - (62 \times 75)}{\sqrt{338 \times 271 \times 258 \times 351}} = 0.54$$

REFERENCES

1. Standards for referral of school children for an eye examination: a preliminary report . . . of committees appointed by the New England Ophthalmological Society . . ., Sight Saving Rev., 23 (4): 223-225, 1953.
2. Leverett, Hollis M., A school vision health study in Danbury, Connecticut, Am. J. Ophth., 39 (4, Pt. 1): 527-540, 1955.
3. Scobee, Richard G., Vision testing of school children, Sight Saving Rev., 20 (2): 88-98, 1950. (Preliminary report of study cited in Reference 4.)
4. Crane, Marian M., Franklin M. Foote, Richard G. Scobee, and Earl L. Green, Screening School Children for Visual Defects. Washington, D. C., Government Printing Office, 1954. Children's Bureau Pub. No. 345.
5. Ryan, Vernon, A critical study of visual screening, Am. J. Optom. and Arch. Am. Acad. Optom., 33 (5): 227-257, 1956.
6. Leverett, Hollis M., An analysis of referrals based on school vision screening tests, Am. J. Optom. and Arch. Am. Acad. Optom., 33 (11): 581-593, 1956.

SIGNAL COLOR RECOGNITION BY COLOR DEFECTIVE OBSERVERS*

Gordon G. Heath† and Ingeborg Schmidt§
Division of Optometry, Indiana University
Bloomington, Indiana

INTRODUCTION

A highly desirable achievement in terms of safety and maximum utilization of manpower would be the establishment of standards for color signal systems which would permit positive signal identification by color deficient observers. As a step in this direction, Judd[1] in 1952 proposed specifications, based on theoretical considerations,[2] for a three-color system of red, blue and green pilot lights for instrument panels. The limiting chromaticities of these lights are shown on the C.I.E. diagram in Figure 3. In 1955 Sloan and Habel[3] found that the ability of color deficient persons to differentiate red and green *point* light sources within Judd's chromaticity limits varied with the intensity of the stimulus and with the degree of the defective color vision. Their findings indicated also that the chromaticity limits specified by Judd must be rigidly maintained if any color deficient subjects are to use this red-green signal system. The signals were presented as single lights with steady exposure which permitted leisurely foveal examination. In view of the promising results of Sloan and Habel the present investigation was undertaken to determine the influence of additional conditions encountered in aviation, namely the occurrence of signals as short flashes, both as spatially isolated lights and also as signal lights in the neighborhood of other non-signal, background lights. It was intended to show also whether, under these circumstances, signals of Judds proposed chromaticities revealed their superiority when intermixed with signals having boundary and nonstandard chromaticities.

APPARATUS

The testing room was divided into two sections, a smaller room for the apparatus and the operator, and a larger one for the observer.

---

*Read before the annual meeting of the American Academy of Optometry, Boston, Massachusetts, December 15, 1958. For publication in the August, 1959, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

This study was supported in whole or in part by the United States Air Force under contract number AF (657)—121, monitored by the School of Aviation Medicine, USAF, Randolph Air Force Base, Texas.

†Optometrist, M.S., Member of faculty, Fellow, American Academy of Optometry.
§M.D. Member of faculty.

The observer faced a dark gray wall, the test flash appearing at its center. A 4 x 8 ft. section of the wall surrounding the test light contained a random pattern of 90 apertures approximately 1 mm. in diameter, which could be uniformly illuminated from the rear to provide a pattern of either red or white background lights, as desired. Selection of color was accomplished by the operator by positioning a lever on the back of the apparatus (Figure 1), which controlled a sliding panel

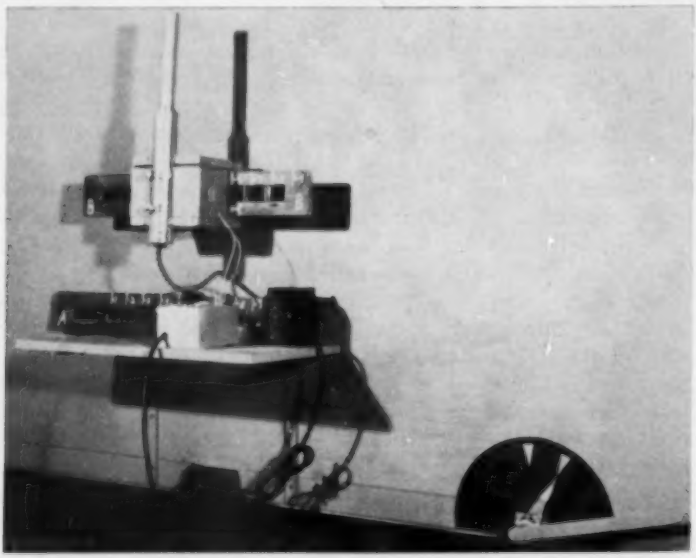


Fig. 1. View of the apparatus from the operator's side. Filter slide B is in position in the projector. Below the projector are slide A, the speed control assembly, and the 6 V transformer for the projector bulb. At lower right is the lever for operating the sliding panel for the background lights, set on "red."

containing duplicate patterns of apertures, one set of which was covered with red filters. The intensity of the background lights (Figure 2) was controlled by varying the number of lamps providing the rear illumination.

A projector mounted on the back of the apparatus (Figures 1 and 2) illuminated the test aperture and provided a wide cone of uniformly distributed light in which the observer was positioned. Single flashes of this light, 0.1 to 0.25 seconds in duration, were provided by an electronically controlled shutter. The color of the test signal was changed by manual insertion of filters in the projector.

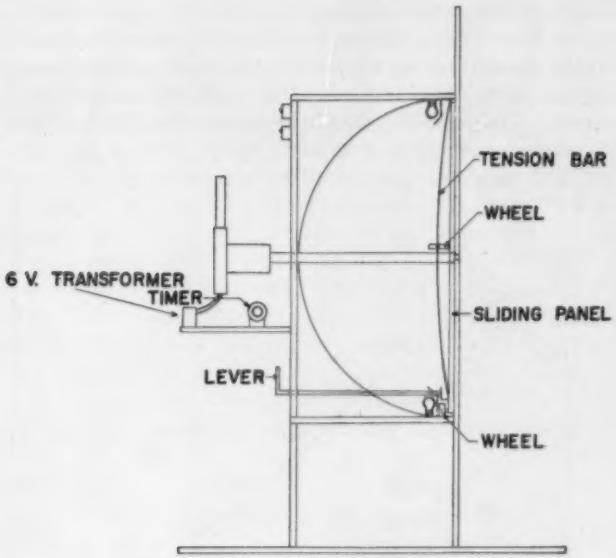


Fig. 2. Vertical section through the apparatus.

In aviation, recognition of signals becomes critical at distances of 1 to 1½ miles. Therefore, the testing situations were designed to simulate the condition of observation from at least 1 mile distance. With the observer seated 2 meters from the test panel, this adaptation to the actual situation concerned:

(a) *The arrangement of the background lights.* In the randomized pattern the minimal distance between lights was 10 cm. This distance corresponded approximately, in angular subtense, to the largest distances between runway lights or obstruction lights on airfields.

(b) *The intensity of the background lights.* The background lights, when shown as white lights of color temperature 2400° K., had a luminance of 82 cd/m² (24 ft-L) and produced an illuminance at the observer's eye of 1.609×10^{-5} lm/m². When shown as red lights their luminance was 42 cd/m² (12.2 ft-L) and they produced at the eye of the observer an illuminance of 8.24×10^{-6} lm/m². The white lights simulated clear runway markers of medium intensity, or house windows, street lights, etc. The red lights corresponded to obstruction red of 20 cd from 1 mile distance.

(c) *The color and intensity of the test light.* The test light,

subtending 1.37 minutes of arc at the observer's eye, was varied in color by means of filters inserted in the projector. Nineteen Wratten gelatin and Corning glass filters were chosen to produce lights of central and boundary chromaticities with respect to the areas limited by Judd's requirements. Their loci in the chromaticity diagram are shown in Figure 3. A twentieth filter, a Wratten #96, nominal N.D. 1.7 was

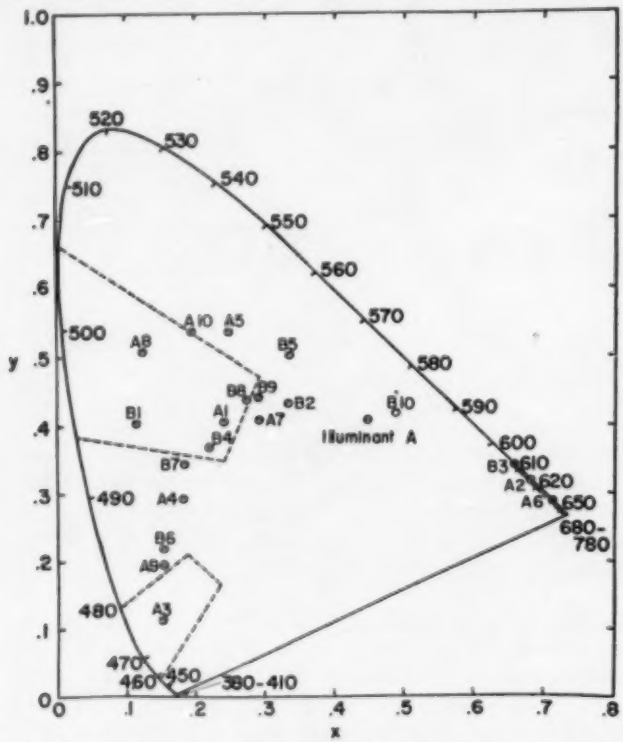


Fig. 3. Loci of signal colors on the chromaticity diagram, designated by the arbitrary serial numbers assigned to the 20 filters used in this study. Also shown are the limits proposed by Judd for chromaticities of red, green, and blue signals.

added to complete the test series. These filters were arranged in random order in two long slides, designated A and B, to facilitate their insertion into the projector.

In order to avoid introduction of too many variables we decided to present the signals at equal intensities for the typical observer, though this would mean decidedly unequal brightnesses for the protan observers.

Therefore, the transmittance of all filters was adjusted by neutral filters to the darkest filter included in this series, filter A3, which had a total visual transmittance of 2.7%, corresponding to an optical density of 1.57.

Two test luminances were utilized. The lower brightness was achieved by placing a N.D. 1.4 filter in the projector in addition to the test filters. The higher brightness was achieved by removing this neutral filter. With color filters in place the illuminances at the eye of the observer were: low level: 4.78×10^{-5} lm/m² (124 mile-candles); high level: 1.194×10^{-3} lm/m² (3092 mile-candles). These illuminances would correspond to the effect of colored light sources of 100 cd. and 3,000 cd., respectively, from 1 mile distance, which in turn correspond with the intensities of the more powerful runway lights and small floodlights.

(d) *Duration of flashes.* The test flashes were similar in duration to those used in aviation signals. We flashed the low brightness signal for 0.1 second and the high brightness signal for 0.1 second and for 0.25 second.

SUBJECTS

Fifty male students and teachers at Indiana University, 21 to 43 years of age, served as observers. 31 had normal color vision, 19 were color defective. Each subject wore his refractive correction during the test if necessary to observe with normal visual acuity. All subjects were tested with a battery of color vision tests, including: AO Pseudoisochromatic Plates for Testing Color Perception, 18 plate selection, 1940; AO H-R-R Pseudoisochromatic Plates for Detecting, Classifying and Estimating the Degree of Defective Color Vision, 1955; Dvorine Pseudoisochromatic Plates, 2nd ed., 1953, and the Nagel Anomaloscope. The classification into normals, protanomals, protanopes, deuteranomals and deuteranopes was made from the findings on the Nagel Anomaloscope.

TESTING PROCEDURE

The subject was seated two meters from the panel. The room was entirely darkened. A chin rest was unnecessary since small excursions of the head did not affect the appearance of the test light. The latter was shown first as a steady light without any background lights. It was explained to the subject that only red, green, blue and white signals would be shown and that some would appear yellowish. The terms he should use to describe the signal should be red, green, blue, white or yellow. When a color appeared doubtful he should give it the name it deserved most from this choice. The names white and yellow were included as permissible responses in this study for several reasons: (1) If not permitted to call a signal "white," subjects hesitated so long in

responding to some test flashes that the response became virtually meaningless anyway so far as identification of the signal was concerned. (2) Such a wide range of chromaticities was employed in this study that responses could not properly be confined only to red, green and blue names. (3) Calls of white and yellow provided a more rigid test of the low saturation limit, particularly of green signals. (4) Most successful use of a color signal system necessitates differentiation of the signal light from other (usually white or yellow-white) lights in the field of view.

Some demonstration tests with flashed signals were given to familiarize the subject with the procedure. The pre adaptation time was the time used for demonstrations and explanations, usually about three to five minutes. During testing no further explanations were given. Before each signal the operator said, "Ready," to prepare the examinee to look in the right direction and concentrate his attention. The subjects were given as much time for the answer as they required, though most subjects, including color defectives, responded promptly. The interval between each presentation was determined by the time the operator needed to write down the color reported by the subject and to change filters. No special adaptation time was given after background lights were turned on.

For convenience backgrounds will be referred to by the letters (a), (b) and (c), as follows: (a) total darkness, (b) dark background containing a random pattern of point sources of incandescent light, (c) dark background containing a random pattern of point sources of red light.

The combinations of signal durations and intensities will be designated as follows: Test I, 0.1 second at low brightness; Test II, 0.1 second at high brightness; Test III, 0.25 seconds at high brightness.

In each of the tests, I, II, and III, the 20 signals were presented five times apiece on each of the three backgrounds. Four different sequences of presentation of the signals were intermixed during each session. A single test session (I, II, or III), comprising 300 signals, lasted about 50 minutes.

Each normal subject was used on only one of the three tests, but most color defective observers were tested on all three conditions because of the relatively low number of subjects available in each of the classes of color deficiency. In such cases the three tests were, as a rule, given on three different days.

RESULTS AND DISCUSSION

The total number of recorded responses was 25,240 (See Table I). Because of the large number of parameters involved (20 filters, 9 test conditions, five classes of observers, and five permitted responses) the

TABLE I

Number of Observations of Each Test Light

	Test I				Test II				Test III				All Conditions
	a	b	c	Total	a	b	c	Total	a	b	c	Total	Total
Normals	51	50	51	152	50	50	50	150	55	55	55	165	467
Deuteranomals	25	25	25	75	25	25	25	75	30	30	30	90	240
Protanomals	15	15	15	45	15	15	15	45	15	15	15	45	135
Deuteranopes	25	25	25	75	30	30	30	90	25	25	25	75	240
Protanopes	20	20	20	60	20	20	20	60	20	20	20	60	180
					Grand total, all observers, all conditions								1262

Test Conditions

Test I—Flash duration 0.1 sec., illuminance 4.78 x 10^{-5} lm/m^2

Test II—Flash duration 0.1 sec., illuminance 1.194 x 10^{-3} lm/m^2

Test III—Flash duration 0.25 sec., illuminance 1.194 x 10^{-3} lm/m^2

a—in total darkness

b—background containing point sources of white light

c—background containing point sources of red light

data will be presented in several ways to permit analysis of the results.

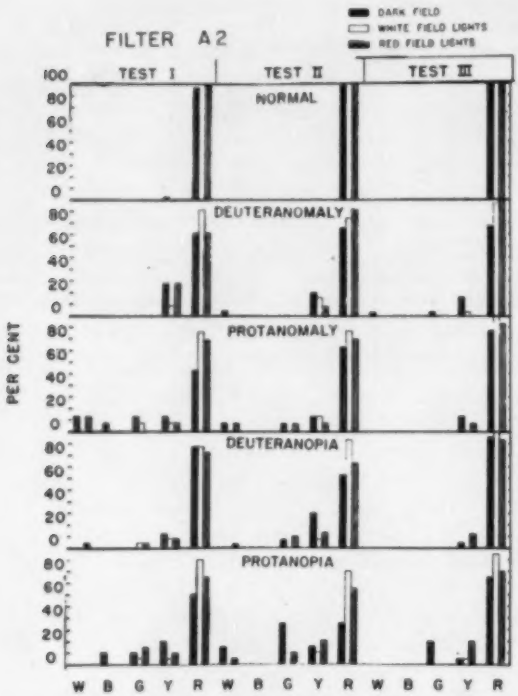
EVALUATION OF EFFECTS OF TEST CONDITIONS

To gain a clearer picture of the effects of signal brightness, flash duration, and background lighting, the data were graphed for each of the 20 filters. Only three such graphs are presented here however (Figures 4-6). In order to facilitate comparison of classes of observers, Figures 4-6 show the responses of "white," "blue," etc., as percentages of the total number of observations (N) of that filter by subjects with each kind of color vision under each of the nine test conditions.

Filter A2 (Figure 4) is a "good" red filter for normal observers, but appears to be a rather poor signal color for color defective subjects, being called "yellow" quite often and "white," "green," and even "blue" less frequently. It can be seen from Figure 4 that, in general, the recognition of this signal by color deficient subjects was improved when the background contains "white" lights. Though observers were never informed that the back ground lights were to be considered as white lights, they apparently took them as a standard for comparison which resulted in an improved performance compared to the dark background. This improvement showed even in the case of the protanopic subject who volunteered a comment about the "pattern of green lights" on this test.

When this A2 signal was presented on background (c), which had the same chromaticity as the test light, performance of color defectives was only slightly better than in complete darkness, and was definitely poorer in most cases than with the "white" field lights.

Increasing the signal brightness and the flash duration improved the performance of color defective subjects, though not enough to compare favorably with the recognition of this color by normal observers even



Figs. 4-6. Representative histograms showing the frequency of calling the color of the designated filter "white," "blue," "green," "yellow," or "red," by each of the five classes of observers, under each of the nine test conditions. N's for each graph are given in Table I.

under the most trying conditions. On Test III the signal was still frequently called "yellow" by all cases of color deficient subjects, and "green" by protanopes.

It cannot be determined from these data what the signal would have been called had the choice of color names been restricted further, say to only "red," "green," and "blue." It may be presumed that most of the "yellow" responses to signal color A2 would then have been "red," since use of the term "yellow" by color deficient observers implies recognition of a long wavelength ("warm") color though of less than maximum saturation. However, the frequency with which this signal was also called "green" by all color defectives except the deuteranomalous indicates the need for caution in any presumptions about the results of further restrictions of color names. In any case, it is evident that even

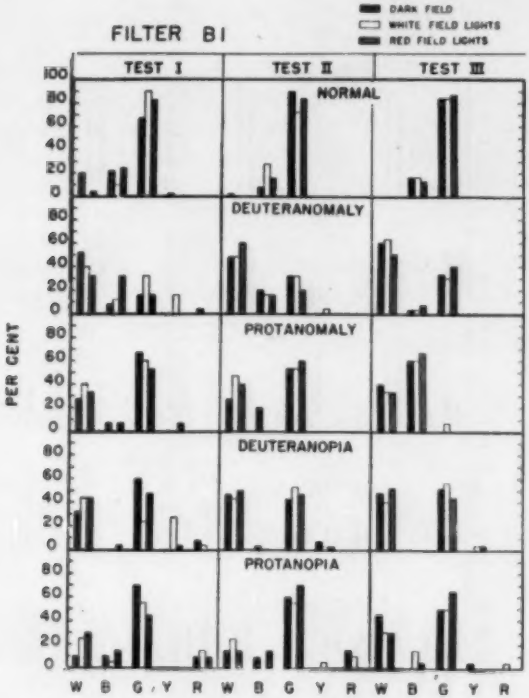


Fig. 5

such a good red signal as this one, well within the limits of Judd's red zone, is not a safe signal for untrained color defective observers under conditions as severe as those used here when seen as a distant small subtense signal, or at least is not safe for subjects with protanomaly, protanopia, or deuteranopia.

The results with two green signals are shown in Figures 5 and 6. The chromaticity of filter B1 is well within Judd's proposed limits for green, while A5 is well outside these limits (Figure 3). Inspection of the data reveals no consistent or predictable effect of background lights on recognition of green signals.

Increases of signal brightness and flash duration did not always result in improved performance, even with normal subjects. Filter A1, for example, was called "blue" by normal subjects most frequently on Test III and least frequently on Test I, though its chromaticity should, according to Judd's specifications, clearly differentiate it from a blue signal. However, Judd did not intend his specifications to be applied to

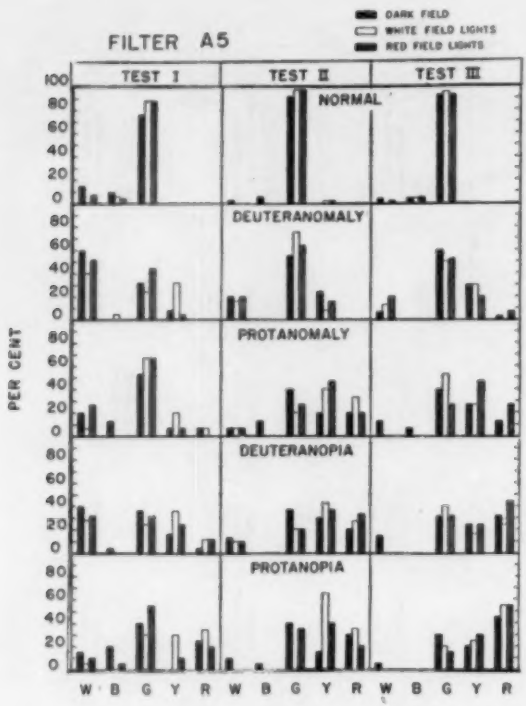


Fig. 6

lights of very small subtense. The high frequency of "white" responses is to be expected from the location of A1 on the chromaticity diagram (Figure 3), fairly close to the low saturation boundary of Judd's green zone. This, in itself, is not objectionable so long as the signal can readily be differentiated from red and blue signals. On this basis a high frequency of "white" responses to a green signal is not necessarily indicative of a poor signal color, though it would suggest that perhaps it would be better to increase the colorimetric purity of the signal color to permit it to be more readily distinguished from other lights in the field of view.

For color defective subjects, increases in signal brightness and flash duration improved performance on some of the green filters or at least gave higher frequencies of "green" responses and lower frequencies of "white" responses, if this can be considered an improvement when the frequencies of "blue," "yellow," and "red" responses remained about the same. For Filter A5 (Figure 6) (outside the limits of Judd's green zone) increases in signal brightness and flash duration markedly in-

creased the frequency of "red" responses, particularly for dichromatic observers.

No clear evidence of a consistent effect of background lighting, signal brightness, or flash duration could be noted with the blue signals, A3 (nearly central in Judd's blue zone), or A9 (just outside the green limit of the blue zone). Filter B6, well outside the blue zone, was called "green" quite frequently by all observers in Test I, but showed improvement on the more favorable Tests II and III.

EVALUATION OF CHROMATICIES

To permit evaluation of the chromaticity limits of Judd's zones, the graphs of Figure 7 were prepared. Since goodness of a signal color

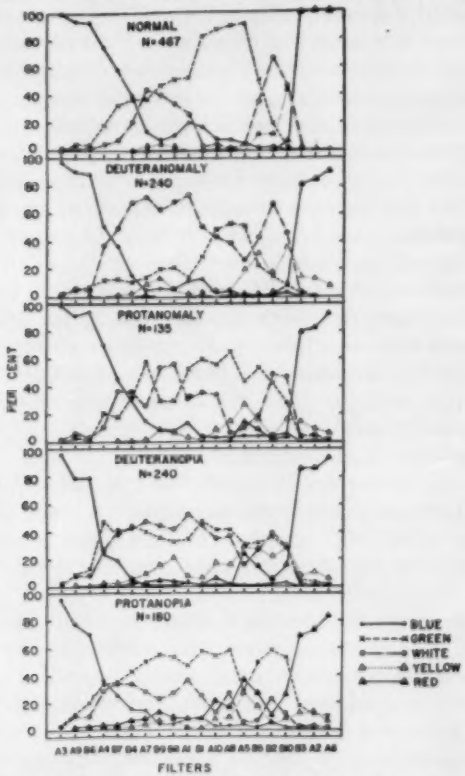


Fig. 7. Frequencies of each of the five responses to each filter presented under all conditions. N's represent the total number of observations of each filter by persons having that particular type of color vision. The order of filters on the abscissa is arbitrary.

implies recognition under all conditions of viewing, and since the differences in recognition afforded by variation of signal brightness, flash duration, and background lighting were found to be relatively minor anyway when compared to the differences afforded by variation of chromaticity, the results of Tests I, II and III and backgrounds (a), (b) and (c) were added to give the data for the graphs of Figure 7. In these graphs the ordinates represent the frequencies of each of the five responses, "white," "blue," "green," "yellow," and "red," for a given class of observers, expressed in per cent of all observations (N) of each filter by that group. The abscissa simply represents an arbitrary order of the 20 filters, selected by empirical arrangement of the filters with regard to frequency of the various normal responses. Though this arrangement resembles somewhat the order that would be obtained on the basis of spectral location of the dominant wavelength of the signal, it should be emphasized that the abscissa is not, in these graphs, a wavelength scale, nor even a uniform scale of any physiological or psychological parameter. This scheme permits a ready evaluation and comparison of the filters for observers with one of the five types of color vision, as well as a comparison of the effects of color deficiency on the recognition of any one signal.

Noticeable at once is the fact that filter A3 was an excellent signal color, recognized as "blue" more than 95% of the time by all kinds of observers. A9 and B6 were also reasonably good blue signals for normal subjects, though they were called "green" about 5% of the time. Clearly, however, these two are not safe signals for color defective observers, for the frequency of "blue" responses falls as low as 70% for protanopic subjects, 78% for deuteranopes, and about 90% for anomalous trichromates.

For red signals, A6 was clearly superior, though A2 and B3 were almost equally satisfactory for normal subjects. Even A6, however, cannot be regarded as a completely safe signal for color defective subjects since it was called "red" less than 95% of the time. It is particularly unsafe for protanopes, who called it "green" in 10% of the presentations.

The errors of the other color defectives usually consisted of calling it "yellow," a somewhat equivocal response which, it might be argued, actually indicated recognition of a "reddish" quality in the signal and so should not be considered erroneous. The validity of this argument is bolstered by the near-parallelism of the "red" and "yellow" curves in the four graphs of color deficient observers' data, for all filters except the three red ones, B3, A2 and A6. However the frequency with which certain green filters such as B9 and A5 were also called "yellow" by these

observers makes it doubtful that "yellow" should be credited as a correct response for the red signal A6.

For green signals, an alarming situation is at once apparent from these graphs. Even for normals no filter gave more than 90% "green" responses except filter A5, which has a chromaticity well outside the limits proposed by Judd. A10, with a borderline green chromaticity, and A8, lying well inside Judd's limits, were called "geen" nearly 90% of the time by normals, but were mistakenly called "blue" about 8% of the time (even though A10 represents the yellowest green permissible in Judd's system).

B4, a color lying well inside Judd's green zone, was actually called "blue" by normal observers more often than it was called "green." B8 and A1, also within Judd's green boundaries though near the white limit of the zone, were called "green" only 50% of the time. Similar difficulties with green signals have been reported by Bouman and Walraven,[4] who found that no spectral light was called "green" more than 50-60% of the time by normal observers even when presented repeatedly with 1.5 sec. flashes and subtending an angle of 50 min. of arc. These results are in strong contrast to those of Holmes[5, 6] who, using an experimental procedure similar to ours, found a very large gamut of chromaticities which were called "green" more than 90% of the time, though at brightness levels much lower than ours. However, Holmes used a flash duration of 1 sec. and permitted as many repetitions of the flash as the observer desired. It is of interest to note that even under these more favorable conditions, Holmes found that the region of chromaticities which gave 95% "green" responses was greatly restricted. Only one of our filters had a chromaticity falling within Holmes' 95% zone. This filter was A5, the best green for our normal observers also, but with a chromaticity well outside Judd's green zone.

For color defective observers the situation is even worse. No signal was called "green" as often as 65% of the time. Filter A5, which was the best green for normal observers, shows a high frequency of "white," "yellow," and "red" responses by color defectives, and is clearly an unsafe color. A10 and A8, though better than A5, were nevertheless called "red" 21% and 16% of the time, respectively, by protanopic observers, and were very frequently called "yellow" and less frequently "red" by observers with other color defects.

Faced with these apparently poor results, it first appeared that any three-color system such as Judd's would be unworkable and unsafe when applied to signals at small subtense. However, several things were observed on the graphs of Figure 7. First, it was noted that for deuter-

anomalous observers the "green" response curve had approximately the same shape as that of the normal observers, but was considerably lower. The deuteranomalous "white" curve, on the other hand, was higher than the normals, especially for the blue-green filters. Both these observations fitted the popular description of deuteranomaly as a so-called "green-weakness."

For deuteranopes it was observed that the "green" and "white" response curves were remarkably similar in shape and height throughout the graph, indicating that these two responses were interchangeable for such observers. Protanopes also showed some, though less, similarity in their "green" and "white" curves. The curves for protanomalous subjects, however, despite marked irregularities, resembled the normals' more than they did the other defectives'. More important was the fact that both the "green" and "white" curves for all color defective observers were highest in the central region of the abscissa, though neither curve reached a height of much more than 50%.

The possibility was apparent then, that the two responses, "green" and "white," taken together, would perhaps be suitable for one signal in a three signal system. In fact, such a system need consist only of colors which could be described as "blue," "red," and "not red or blue." Using this scheme, it can be seen from Figure 7 that all of the filters from B4 to B2 on the abscissa were reasonably good "not red or blue" signals for color defectives. However, if the criterion of 90% correct responses is applied to the data for these filters for color defectives, it is at once seen that no filter was a safe third signal for protanopes. The best "not red or blue" filter for protanopes was B8 which was judged correctly only 87% of the time.

For deuteranomalous observers, filters A7, B9, B8, A10, A8, A5, B5, and B2 were acceptable "not red or blue" signals at the 90% level of certainty. B4, A7, B9, B8, A1, B1, A10, A8 and B2 were suitable for deuteranopes, and B9, B8, B1, A10, A8 and B2 for protanomals. Combining these results, only filters B9, B8, A10, A8 and B2 were safe "not red or blue" signals for color defective observers other than protanopes. Referring to the chromaticity diagram (Figure 3) it is seen that these five colors lie in a band near the upper (yellow-green) border of Judd's zone and also include the desaturated colors outside the white boundary of the zone.

If, as discussed previously, "yellow" responses by color deficient observers may indicate confusion with "red," then it would be unsafe to include "yellow" as an acceptable name for a "not red or blue" signal. However, if "yellow" responses are excluded, the 90% safe filters for

deuteranomalous observers are reduced to only A10 and A8; for protanomalous, B1 and B2; and for deuteranopes, only B1. Thus, with this criterion, no filter may be regarded as a safe third signal for color defectives, even when protanopes are excluded.

CONCLUSION

It should be pointed out that the design of this study was not aimed toward determining whether subjects shown only red, green, and blue signals of Judd's proposed chromaticities could differentiate them from each other. Instead, the experiment was designed to see whether signals having those chromaticities revealed their superiority when intermixed with signals having boundary and non-standard chromaticities. The experiment thus was inherently a more difficult trial for color defective observers, and could be expected to yield less favorable performances on even the best signal colors by all observers than if only "good" red, green, and blue signals had been used. Too, no training on signal recognition was given: there were no demonstrations of what a green or red or blue signal should look like, subjects were not told the colors of background lights, and they were not informed of their errors in identification of signals.

Bearing in mind, then, the relatively severe conditions imposed during these tests, and the fact that many signals besides Judd's recommended ones were employed, examination and analysis of our data yields the following conclusions:

For signals seen as single short point-source flashes with foveal or near-foveal vision at intensity levels producing approximating 100 to 3000 mile-candles at the eye:

1. The presence of other lights in the field, either white or red, of lower brightness than the signal, in general slightly improved the ability of all observers to identify the signal color correctly. The improvement was most marked for certain green signals, was less pronounced for red and blue signals, and was of greater importance for color defective observers than for normals.

2. Increasing the signal brightness and/or flash duration generally improved recognition of signal colors by all observers, with the important exceptions that (a) normal observers (and, to a lesser extent, color defective observers also) called certain (bluish-green) green signals "blue" much more frequently at high brightness than at low. (b) Color defective observers called certain (yellowish-green) green signals "red" much more frequently at high brightness than at low.

3. The chromaticity limits recommended by Judd for blue signals, though not tested thoroughly, may be too generous when applied

to signals of small subtense. A signal of central blue chromaticity was correctly identified by all observers more than 95% of the time, but signals having chromaticities just outside Judd's limits were called "green" or "white" even by normal observers six per cent of the time, and as often as 27% of the time by protanopes. Protanopes also called these signals "red" on a very few occasions (two to three per cent).

4. Judd's recommended chromaticity limits for red signal colors when applied to signals of small subtense, may or may not be too generous, depending on the criterion of correctness of recognition used. Protanopes on the average correctly identified signals within these limits as "red" less than 80% of the time though the presence of other lights in the field markedly improved performance and in some cases gave 100% recognition of the most extreme red signal used in these experiments. Subjects with other color defects did well on this same signal (better than 90%), but called another red signal with a chromaticity well inside Judd's limits "yellow" about 10%, and "green" two to three per cent of the time. Recognition of a third red, lying just outside Judd's limits, was only slightly poorer for all observers. Thus, if "yellow" responses by color defectives are considered correct for identification of red signals, then Judd's limits are unnecessarily restrictive, even for signals of small subtense. If only "red" responses are considered to constitute correct recognition of the signal color, Judd's specifications are not sufficiently restrictive on the yellow limit.

5. Evaluation of the chromaticity limits for green signals involves several considerations. For normal observers the best green lies near or outside the yellow limit of green chromaticities suggested by Judd. Even the best green, however, was a poorer signal than blue or red, being correctly identified only about 90% of the time by normal subjects. The best green for normals was frequently confused with red, yellow, or white by color deficient observers. To afford ready differentiation from red or yellow by such observers it is necessary to use a bluish-green signal, which then may be miscalled as "blue" by normal persons and by some color defectives.

Maximum recognition of a "not red or blue" signal by all observers would therefore appear to require further restriction of the blue limit of Judd's green zone. For such a three-color system, the present yellow limit would be satisfactory, and the white limit becomes unimportant by this criterion.

However, blue lights are usually not employed in long distance signal systems, principally because of the low transmittance of available blue glasses. Therefore, the small subtense confusion of green and

blue by normal observers[7] (foveal tritanopia) and, to a lesser extent by color defective observers,[8] may not be a very serious problem, particularly if such signals are readily differentiated from red signals by all observers. In other words, this argument is simply a statement that only a two-color signal system is necessary for distant signals, but the two colors should also be usable in a three-color signal system employing lights of larger subtense.

On this basis it would appear that Judd's specifications for green signals represent about the best compromise for the various requirements of both a two-color and a three-color system, although greater restriction of the yellow limit might be advisable. This would permit easier differentiation of the green signal from red in a two-color distant signal system for all observers, while still permitting it to be differentiated from a blue signal when used in the three-color, larger-subtense signal system.

The most serious problem encountered in the use of either or both of these signal systems, however they may be modified, is the performance of protanopes. Protanopic observers, unless special precautions are taken, are prone to confusion of even the most carefully selected chromaticities. Further studies should be undertaken to determine whether these subjects, given a minimum of training and provided with some sort of comparison standard in the field of view, can perform quite safely and satisfactorily with a signal system employing Judd's specification, with or without our recommended modifications.

ACKNOWLEDGMENT

The authors wish to thank Capt. Donald G. Pitts, U. S. Air Force, for his assistance in the measurements and computations of colorimetric data and the testing of subjects.

REFERENCES

1. Judd, Deane B., Standard Color Filters for Electronics Equipment. Ann Arbor, Mich., Armed Forces-National Research Council, Vision Committee Secretariat, University of Michigan, 1952.
2. Sloan, Louise L. and Adelaide Habel, Color signal systems for the red-green color blind, J. Opt. Soc. Am., 45 (8): 592-598, 1955.
3. Sloan, Louise L. and Adelaide Habel, Recognition of red and green point sources by color-deficient observers, J. Opt. Soc. Am., 45 (8): 599-601, 1955.
4. Bouman, M. A. and P. L. Walraven, Some color naming experiments for red and green monochromatic lights, J. Opt. Soc. Am., 47 (9): 834-839, 1957.
5. Holmes, J. G., The recognition of colored light signals, Trans. Illuminating Engineering Soc., 6:71-97, 1941.
6. Holmes, J. G., Colour recognition of very small light sources, Documenta Ophthalmologica, 3: 240-250, 1949.
7. Willmer, E. N. and W. D. Wright, Colour sensitivity of the fovea centralis, Nature, 156: 119-121, 1945.
8. Farnsworth, Dean, Preliminary Report on Confusions of Colored Lights at Small Subtense by Protans and Deutans, New London, Conn., Medical Research Department, Naval Submarine Base, Sept., 1946. Color Vision Report No. 13.

AMERICAN JOURNAL OF OPTOMETRY
and ARCHIVES *of*
AMERICAN ACADEMY OF OPTOMETRY
Established 1924

Vol. 36 August, 1959 No. 8

EDITORS AND STAFF

Dr. Carel C. Koch ..... *Editor*
Dr. Monroe J. Hirsch ..... *Associate Editor*
Dr. Rudolph Ehrenberg ..... *Advertising Manager*
Terry Judith Parkins ..... *Editorial Assistant*
Grace Weiner ..... *Bibliographic Editor*

Publication and Academy Office: 1508 Foshay Tower, 821 Marquette Ave.
Minneapolis 2, Minnesota

Annual Subscription, United States and Canada, $8.00 in Advance; Foreign, $9.00; Single Copies 80c

Original papers, scientific communications, clinical reports, books for review, and correspondence should be sent to the editor. Subscriptions and applications for single copies should be addressed to the circulation manager. Copy of advertisements must be sent in by the first of the month preceding their appearance. Communications with reference to advertising or other journal business should be addressed to the advertising manager. Academy correspondence should be addressed to Dr. Carel C. Koch, Secretary of the American Academy of Optometry.

Published Monthly by the
AMERICAN JOURNAL OF OPTOMETRY PUBLISHING ASSOCIATION

The American Academy of Optometry and the publishers of this journal have no objection to the reprinting by other magazines of any of the articles in this issue, provided such reprints are properly credited to the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

PRESENTING A REVIEW OF ACADEMY POST-GRADUATE COURSES

A review of the 5th annual Academy post-graduate course series, scheduled for all optometrists at Chicago, December 9, 10, 11, 1959, at the Drake Hotel, is presented on following pages. This exceptional collection of 64 courses, each given by an outstanding specialist in his subject, is the largest and we believe to be the finest example of post-graduate education ever offered the profession. These courses are offered under the supervision of Dr. V. J. Ellerbrock, Columbus, and his committee. They have hand-picked their instructors from private practice and from our schools and colleges and in so doing have again presented an array of talent entirely typical of Academy events. Every member of the profession is invited to take part. For most classes attendance is limited only by the size of the lecture rooms. In spite of this, advance registration is suggested.

CAREL C. KOCH

TRANSACTIONS OF THE ACADEMY
AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data news, professional problems and ideals, as these relate to the Academy.

AMERICAN ACADEMY OF OPTOMETRY
POST-GRADUATE COURSES
Drake Hotel
Chicago, Illinois
December 9, 10, 11, 1959

GENERAL INFORMATION ON POST-GRADUATE COURSES

Time: All courses are scheduled for the three days immediately preceding the regular annual meeting of the Academy.

Place: All of the courses will be taught in the Drake Hotel.

Applicants: Any optometrist may apply for one or more courses. However, Academy Fellows have preference in advance registration until September 21, 1959.

Cancellation: In case of cancellation by applicant the fee will be returned, providing such cancellation is received no later than November 21, 1959.

Cost: The cost per hour of instruction is $2.00 unless otherwise specified.

Enrollment: For most courses the enrollment is not limited. Several specialized courses, however, are limited in enrollment as indicated in the description of courses.

Number of Courses: Sixty-four (64).

Hours of Instruction: One hundred and fifty-four (154).

Applications: All applications should be sent to Dr. D. G. Hummel. The National City Bank Bldg., Cleveland, Ohio.

Deposit: One-half the total fee for each course must accompany the application. The balance must be paid at the commencement of the courses. Courses limited in enrollment must be accompanied by the full fee.

Tickets: Without exception, everyone enrolled in a course must register and pick up the appropriate ticket. Without it, no one can be admitted.

Lecture Rooms: These will be posted at the registration desk. The hotel bulletin board will state the location of the registration desk. Please check your time schedule of courses. The Committee cannot be responsible for conflicts of scheduling.

COMMITTEE ON INSTRUCTION
V. J. ELLERBROCK, Chairman
R. E. BANNON
M. C. FLOM

COMMITTEE ON ADMINISTRATION
D. G. HUMMEL, Chairman
R. EHRENBERG
M. H. KAUHL

Course 1
Subjective and Objective Refractive Instruments

Merrill J. Allen, O.D., Ph.D.
Bloomington, Indiana

A one-hour course—$2.00

Period: T-4

A discussion of recent research optometers and their importance in refractive office procedures. The specifications for a simple research-type vernier optometer also will be discussed.

Course 2
Physiological Optics — Entoptic Phenomena

Merrill J. Allen, O.D., Ph.D.
Bloomington, Indiana

A two-hour course—$4.00

Periods: T-10, T-11

Demonstration, discussion and application of such entoptic phenomena as: Haidinger's brushes, Maxwell's spot, blue arcs, muscas volitantes, "galloping gadgets," Purkinje's figure, phosphenes and the entoptic view of the pupil and opacities.

SCHEDULE OF COURSES BY HOURS

Hour	Wednesday					Thursday					Friday				
8:00 A.M.	39	47	62	58		9	32	16	12		6	61	55	17	
9:00 A.M.	39	47	62	58		9	32	16	25		6	61	55	38	
10:00 A.M.	59	19	54	28		41	19	2	35		8	10	44	31	
11:00 A.M.	59	19	54	28		41	19	2	35		8	45	27	18	
12:00 Noon	63	50	56	49		26	20	36	49		23	52	36	49	
1:00 P.M.	63	50	56	49		22	20	36	49		13	52	36	49	
2:00 P.M.	46	19	54	48		46	19	51	5		46	15	11	64	
3:00 P.M.	46	19	54	48		46	19	51	5		46	15	11	64	
4:00 P.M.		60	53	37		29	1	53	37		30	3	53	37	
5:00 P.M.		40	53	37		29	40	53	37		30	40	53	37	
6:00 P.M.	46					46					46	33			
7:00 P.M.	46					46					46	34			
Evening	4	14	57	42	7	4	14	57	21	7	4	14	24	43	

Course 3
Efficiency and the Eye Examination
Merrill J. Allen, O.D., Ph.D.

Bloomington, Indiana

A one-hour course—$2.00

Period: F-4

Refinements in test procedures and instrumentation to increase speed or permit more complete testing. Keratometry, retinoscopy, the subjective, phorias, ductions and patient control will be discussed.

Course 4
Visual Training and Speed Reading
Louis Anapolle, O.D.

Boston, Mass.

A six-hour course—$24.00

Periods: W-E, T-E, F-E

Effective reading course for students, adults in the business or professional world, and in industry. The course will include demonstrations of practical visual training techniques for reading acceleration and comprehension improvement: tachistoscopic training procedures, controlled acceleration techniques, reading efficiency methods (pre-reading, skimming, key word reading, etc.) and progress tests to evaluate advancement.

Course 5
Accounting and Office Procedure
Otto J. Bebber, O.D.

Denver, Colorado

A two-hour course—$4.00

Periods: T-2, T-3

Methods of charging for professional services and recommended accounting practices to simplify tax and office procedures. The role of credit and methods for handling delinquent payments also will be considered.

Course 6
Theory and Practice of Tonometry
John H. Carter, O.D.

Bloomington, Indiana

A two-hour course—$4.00

Periods: F-8, F-9

Discussion of techniques, provocative tests, interpretation of results and the criteria for patient referral.

Course 7
Streak Retinoscopy
J. C. Copeland, O.D.

Chicago, Ill.

A four-hour course—$8.00

Periods: W-E, T-E

This course is intended for those who wish to improve their skills in objective testing. Many innovations in teaching the Streak Technique will make the course of special interest to both those who now use the Streak Retinoscope and those who desire to begin its use. Each student will be provided with the necessary equipment including a retinoscope, schematic eye, transformer and lenses. The course is conducted so as to give each man personal supervision and instruction as well as lectures for the group.

Course 8
Fundamentals of Aspheric Lenses
John K. Davis

Southbridge, Massachusetts

(By Invitation)

A two-hour course—$4.00

Periods: F-10, F-11

Description of aspheric lenses, what they can and cannot do. Attention will especially be devoted to cataract, microscopic and magnifier lenses.

Course 9
Practice Management
Ramie B. Dick, O.D.

Sandusky, Ohio

A two-hour course—$4.00

Periods: T-8, T-9

Records for a recall system, and other office procedures will be discussed and statistics on the relative values of mailing and telephone recall systems presented. The effective use of assistants, modern office techniques, intercoms, postage

KEY TO DESIGNATION OF PERIODS

Time	Wednesday	Thursday	Friday
8:00 A.M.	W-8	T-8	F-8
9:00	W-9	T-9	F-9
10:00	W-10	T-10	F-10
11:00	W-11	T-11	F-11
12:00	W-12	T-12	F-12
1:00 P.M.	W-1	T-1	F-1
2:00	W-2	T-2	F-2
3:00	W-3	T-3	F-3
4:00	W-4	T-4	F-4
5:00	W-5	T-5	F-5
6:00	W-6	T-6	F-6
7:00	W-7	T-7	F-7
8:00	W-E	T-E	F-E

Note: In program of Courses, (E) denotes 8:00 P.M. Evening Course.

meters, dictaphones, and electric typewriters and similar aids will be reviewed. The public relations value as well as their efficiency will be evaluated.

Course 10
Accounts Receivable Control
Ramie B. Dick, O.D.
Sandusky, Ohio
A one-hour course—$2.00
Period: F-10

With increasing demands for credit it is imperative the optometrist maintain accurate records of his accounts receivables. Various systems are available and will be reviewed. Special emphasis will be placed on the *Todd-Hadley-Write-It-Once-System* which was designed especially for doctors. It provides positive daily accounts receivable control and is well adapted to optometric practice.

Course 11
New Trends in Cosmetic Dispensing
Margaret Dowaliby, O.D.
Los Angeles, Calif.
A two-hour course—$4.00
Periods: F-2, F-3

Discussion of the newest designs in eyewear (frame and lenses) that result in a better appearing and functioning pair of glasses for a patient.

Course 12
Modern Plastic Lenses and Their Clinical Applications
Margaret Dowaliby, O.D.
Los Angeles, Calif.
A one-hour course—$2.00
Period: T-8

Plastic ophthalmic lenses have a number of advantages over glass lenses but also a number of shortcomings. These will be discussed in detail on the basis of recent experimental findings. The course includes the use of plastic lenses in multifocal corrections, special absorptive features, aspheric surfaces and as aids for limited vision.

Course 13
Visual Acuity Testing Charts
Arthur A. Eastman
Cleveland, Ohio
(By Invitation)
A one-hour course—$2.00
Period: F-1

A review of the types of acuity testing charts, the theory behind each design and a discussion of the factors which influence their effectiveness. A new design of a testing chart will be presented with a discussion of its advantages.

Course 14
Sub-Normal Vision and Clinic
William Feinbloom, O.D., Ph.D.
New York, N. Y.
Irving Filderman, O.D.
Memphis, Tenn.
Edward Williams, O.D.
Denver, Colorado
A six-hour course—$24.00
(Limited to 20 students)
Periods: W-E, T-E, F-E

A combined lecture and clinic course designed to present and analyze problems of the partially blind patient. The application of visual aids in caring for these patients will be covered in detail.

Course 15
The Physiological Optics of the Partially Blind Eye
William Feinbloom, O.D., Ph.D.
New York, N. Y.
A two-hour course—$4.00
Periods: F-2, F-3

The effect of pathology and abnormalities on the physiological optics of the normal eye. The material presented in this course will enable the practitioner to better screen, understand, and aid his partially blind patients.

Course 16
Accommodation and Convergence with Contact Lenses
Leon E. Firestone, O.D.
Detroit, Michigan
A two-hour course—$4.00
Periods: T-8, T-9

Effects of contact lenses on accommodation and convergence, induced prisms from different manufacturing techniques, apparent accommodative changes from image size and practical application in Optometry.

Course 17
Evaluation of Quality in Ophthalmic Lenses
Glenn A. Fry, O.D., Ph.D.
Columbus, Ohio
A one-hour course—$2.00
Period: F-8

For several years the instructor has been Chairman of the Standards Committee of the A.O.A. and represents Optometry on the American Standards Association Committee on spectacle lenses. He will demonstrate methods of testing ophthalmic lenses for quality and show what defects cannot be permitted and how defects can most readily be detected.

Course 18
Vision Discomfort — Role of Glare Sources and the Pupil
Glenn A. Fry, O.D., Ph.D.
Columbus, Ohio
A one-hour course—$2.00
Period: F-11

Under normal circumstances, the adaptive mechanism to illumination include not only photochemical changes in the retina but also alteration in the size of pupil. Glare sources constitute a particular problem in adaptation due to the restricted size of retinal image. The role of such sources and the pupil in vision discomfort as well as the responsibility of the optometrist in providing relief will be considered.

Course 19
Advanced Course on Corneal Lenses
Robert Graham, O.D.
Pasadena, Calif.
William Feinbloom, O.D., Ph.D.
New York, N. Y.
Frank Dickinson, F.B.O.A.
Lancashire, England
An eight-hour course—$32.00
(Attendance Limited)
Periods: W-10, W-11, W-2, W-3, T-10, T-11, T-2, T-3

Techniques for success in fitting modern corneal lenses; methods for securing optimum results in regular cases as well as procedures employed in handling the more difficult problems. The course is for those who already have substantial experience in the fitting of corneal contact lenses.

Course 20
Ocular Manifestations or Systemic Diseases
Theodore Grosvenor, O.D., Ph.D.
Houston, Texas
A two-hour course—$4.00
Periods: T-12, T-1

Presentation of the effects of systemic diseases upon the eye, their effects upon innervation and motility, and their indirect effects upon vision. Special attention will be given to the role of childhood diseases.

Course 21
Recent Advances — Illumination Requirements and Lighting Design
Sylvester K. Guth, E.E., D.O.S.
Cleveland, Ohio
(By Invitation)
A two-hour course—$4.00
Period: T-E

New information on the effect of light and lighting on visual performance and visual comfort. The basic principles involved in providing good seeing conditions and how these principles are applied in practice will be discussed.

Course 22
The Badal Optometer
Gordon G. Heath, O.D., Ph.D.
Bloomington, Indiana
A one-hour course—$2.00
Period: T-1

Demonstration of the use of the Badal optometer; its principles and construction; its advantages and disadvantages for specific purposes. Techniques for verification of subjective refraction, measurement of amplitude of accommodation, and application to visual training.

Course 23
Stigmatoscopy
Gordon G. Heath, O.D., Ph.D.
Bloomington, Indiana
A one-hour course—$2.00
Period: F-12

The stigmatoscope as an optometric instrument. Its use in measurement of spherical correction, astigmatism, binocular balance, heterophoria, accommodative amplitude, and determination of presbyopic adds. Comparison of stigmatoscopic and conventional findings.

Course 24
Office Use of the Recording Haploscope
Gordon G. Heath, O.D., Ph.D.
Bloomington, Indiana

A two-hour course—$4.00
Period: F-E

Demonstration of the recording Haploscope now available for office use, with discussion of the principles of haploscopic testing of binocular vision, including measurement of refractive error, phorias, ductions, and accommodative functions.

Course 25
Visual Fields with Multi-pattern Test Targets
Frederick W. Hebbard, O.D., Ph.D.
Columbus, Ohio
A one-hour course—$2.00
Period: T-9

Discussion and demonstration of multiple-pattern visual field screening techniques using tachistoscopic presentation of targets. Consideration of the advantages and limitations of such techniques, particularly with regard to detection of glaucoma.

Course 26
Supplementary Methods of Investigating Heterophorias
Frederick W. Hebbard, O.D., Ph.D.
Columbus, Ohio
A one-hour course—$2.00
Period: T-12

A discussion and demonstration of some additional procedures, such as the Lancaster screen, which may be used in clinical investigation of heterophorias, together with their application in case analysis and prescription.

Course 27
Flicker Fusion: Principles and Applications
Frederick W. Hebbard, O.D., Ph.D.
Columbus, Ohio
A one-hour course—$2.00
Period: F-11

Discussion of flicker perimetry, especially as an aid to early detection of glaucoma, with a demonstration of a new form of flicker-fusion apparatus applicable to clinical practice.

Course 28
Refractive Changes Throughout Life
Monroe J. Hirsch, O.D., Ph.D.
Ojai, California
A two-hour course—$4.00
Periods: W-10, W-11

New data on the expected refractive changes with age will be presented with special emphasis on the value of this data in prognosis from the statistical point of view. The author is co-editor of a text in press on *"Geriatrics."*

Course 29
Recent Advances in Ocular Anatomy and Neurology
Harry A. Jankiewicz, Ph.D.
Los Angeles, Calif.
A two-hour course—$4.00
Periods: T-4, T-5

The filtration angle region related to glaucoma. Significance of the medial root of the optic tract. Nuclei of the oculomotor nerve. The vestibular apparatus and the eye. Convergent-accommodation reflex.

Course 30
Microbiology in Contact Lens Practice
Harry A. Jankiewicz, Ph.D.
Los Angeles, Calif.
A two-hour course—$4.00
Periods: F-4, F-5

The most important bacteria, viruses and protozoa causing ocular diseases. Contamination of wetting agents and fluorescein. Mechanisms of destroying agents causing disease. Avoiding infection.

Course 31
Binocular Nearpoint Testing Technique
Louis Jaques, O.D.
Los Angeles, Calif.
A one-hour course—$2.00
Period: F-10

A new technique for testing the refractive correction of each eye separately at the near point under conditions of binocular vision. The design of a system to impliment the test will be described and the significance of the measurements discussed.

Course 32
The Care and Adjustment of Ophthalmic Instruments
Fred W. Jobe
Rochester, N. Y.
(By Invitation)
A two-hour course—$4.00
Periods: T-8, T-9

Ophthalmic instruments, like other types of precision measuring devices, necessitate adequate care and adjustment for maximum efficiency. These will be presented for all types of refracting instruments with special emphasis on the ones commonly employed in contact lens practice.

Course 33
Analysis and Use of Blended Bifocals
Henry A. Knoll, Ph.D.
Rochester, N. Y.
A one-hour course—$2.00
Period: F-6

The construction of several blended bifocals and a method of their measurement will be described. Their use as a cosmetic lens will be discussed.

Course 34
Use of Fresnel Lenses for Magnification
Henry A. Knoll, Ph.D.
Rochester, N. Y.
A one-hour course—$2.00

Period: F-7

Plastic Fresnel lenses are very much lighter than glass or plastic lenses of conventional construction. Several problems concerning these lenses will be discussed—image quality, cleaning problems, and availability of powers.

Course 35
Diagnosis of Amblyopia vs. Central Scotomata
J. Donald Kratz, O.D.

Souderton, Pa.

A two-hour course—$4.00

Periods: T-10, T-11

Various techniques to differentiate amblyopia, suppression, and central scotomas. The prognosis for the various types of central field loss associated with strabismus and amblyopia will be discussed.

Course 36
Ocular Motility on the Clinical Level
Marshall V. Mark, O.D.

Boston, Mass.

A four-hour course—$8.00

Periods: T-12, T-1, F-12, F-1

A practical presentation of the physiology and pathology of the extrinsic muscles. Subjective and objective techniques for investigating and diagnosing defects of the ocular motor apparatus also will be considered.

Course 37
Slit Lamp Microscopy in Contact Lens Practice
Bernard Mazow, O.D.

Houston, Texas

A six-hour course—$24.00

(Limited to eight)

Periods: W-4, W-5, T-4, T-5, F-4, F-5

Fundamentals of biomicroscopy with emphasis on the mechanics and use of the instrument. Special attention will be given to the use of the slit lamp in contact lens fitting.

Course 38
The Pupilens
Bernard Mazow, O.D.

Houston, Texas

A one-hour course—$2.00

Period: F-9

Theory and demonstration of limited aperture contact lenses for the correction of presbyopia and sub-normal vision.

Course 39
Ophthalmic Prisms
Meredith W. Morgan, O.D., Ph.D.

Berkeley, Calif.

A two-hour course—$4.00

Periods: W-8, W-9

Brief discussion of the distortions created by ophthalmic prisms. Various useful methods for the prescribing of prisms will be presented.

Course 40
Summary of Bangerter Technique for Training Amblyopia
Meredith W. Morgan, O.D., Ph.D.

Berkeley, Calif.

A three-hour course—$6.00

Periods: W-5, T-5, F-5

Summary of methods used by Bangerter in training amblyopic subjects. Certain modifications will be suggested to make the method applicable in the average office using inexpensive equipment. A brief discussion of eccentric fixation will be given.

Course 41
Turville Infinity Balance Test
Meredith W. Morgan, O.D., Ph.D.

Berkeley, Calif.

A two-hour course—$4.00

Periods: T-10, T-11

The Turville infinity binocular balance technique for determining the subjective refractive error of each eye while maintaining single binocular vision will be demonstrated. The utilization of the method, frequently referred to as the TIB technique in practice, will be discussed. The prescribing of base-in and vertical prisms will be described.

Course 42
Corneal Contours in Contact Lens Practice
Harold I. Moss, O.D.

Wilmington, Del.

A two-hour course—$4.00

Period: W-E

Recent data on corneal contours; particular attention will be given to the role of this data in the design of the base and peripheral curves of a corneal lens. The significance and causes of corneal exhaustion also will be included.

Course 43
Astigmatism and Contact Lenses
Harold I. Moss, O.D.

Wilmington, Del.

A two-hour course—$4.00

Period: F-E

Irregular, residual and induced astigmatism as it applies to contact lens practice. The application of corneal and haptic lenses in correction.

Course 44
Contact Lens Records, Forms and Routine
Herbert L. Moss, O.D.

Woodbridge, N. J.

A one-hour course—$2.00

Period: F-10

An efficient routine in the design and fitting of contact lenses will be discussed and recommended record forms to impliment the routine will be presented.

Course 45
Cosmetic Contact Lenses
Herbert L. Moss, O.D.
Woodbridge, N. J.
A one-hour course—$2.00
Period: F-11

The design and fitting of haptic contact lenses for obscuration of ocular disfigurement. Relevant cases will be presented and discussed.

Course 46
Technique of Microlens Fitting
John C. Neill, O.D.
Philadelphia, Pa.
Frank Dickinson, F.B.O.A. (Hons.)
Lancashire, England
And Associates
A twelve-hour course—$48.00
Periods: W-2, W-3, W-6, W-7, T-2, T-3, T-6, T-7, F-2, F-3, F-6, F-7

Lectures and practical work in the clinical fitting of patients with microlenses.

Course 47
Legal Aspects of Optometric Practice
Charles W. Ott, O.D.
Chicago, Illinois
A two-hour course—$4.00
Periods: W-8, W-9

Common law (not the statutory optometric practice acts) as it applies to the average practice. Topics covered would include Agency, Credit and Collection, Express and Implied Contracts, Office Leases, Torts and Malpractice, and Wills and Intestacy.

Course 48
Optometric Partnerships, Associateships, and Transfer of Practices
Charles W. Ott, O.D.
Chicago, Illinois
A two-hour course—$4.00
Periods: W-2, W-3

Advantages and disadvantages of partnership and associateship practices from legal, economic and social viewpoints, with particular reference to forming a partnership or association between the well-established optometrist and the recent graduate.

Course 49
Adjustment and Modification of Contact Lenses
William W. Policoff, O.D.
Wilkes-Barre, Pa.
A six-hour course—$24.00
(Limited to twenty students)
Periods: W-12, W-1, T-12, T-1, F-12, F-1

A laboratory course covering the following subjects: changing diameter of lenses, refinishing edge of lens, reducing optical zone, changing radius of peripheral radius on concave side of lens, reducing edge thickness of lens, removing fine surface scratches from convex and concave surface of lens, changing small amounts of power in the lens, and Con Lish edge finishing.

Course 50
Basic Principles of Magnification as Applied to Aniseikonic Corrections (Prerequisite for Courses 51 and 52)
Arline W. Rayner, B.Sc.
Southbridge, Mass.
(By Invitation)
A two-hour course—$4.00
Periods: W-12, W-1

Aniseikonic corrections and how they may be provided by ophthalmic lenses. Basic principles of magnification in spectacle lenses and trial lenses will be included.

Course 51
Comprehensive Course on the Design of Aniseikonic Corrections (Prerequisite: Course 50)
Arline W. Rayner, B.Sc.
Southbridge, Mass.
(By Invitation)
A two-hour course—$4.00
Periods: T-2, T-3

Lecture and workshop on the application of the theory discussed in Course 50. Translation of eikonometer findings, methods of computing the lenses, and design choice in relationship to fabrication will be included. Charts and tables to shortcut the computing will be introduced.

Course 52
Simplified Procedure for Designing Iseikonic Lenses (Prerequsite: Course 50)
Arline W. Rayner, B.Sc.
Southbridge, Mass.
(By Invitation)
A two-hour course—$4.00
Periods: F-12, F-1

Covered by this approximate translation procedure are those corrections which can be furnished by nonbitoric lenses ground in local laboratories from standard blanks. The interpretation of eikonometer reading and test lens set-up in relationship to this procedure will be discussed.

Course 53
Subnormal Vision
Alfred A. Rosenbloom, Jr., O.D,
Chicago, Illinois
William Policoff, O.D.
Wilkes-Barre, Pa.
A six-hour course—$12.00
Periods: W-4, W-5, T-4, T-5, F-4, F-5

All aspects of the problem are considered, including definition, causes, psychological factors, patient selection, examination techniques, consideration in selecting the appropriate visual aid, and adaptive training procedures. Both the

problems of the education and of the rehabilitation of the partially blind will be considered. The course will include a clinical demonstration of examination techniques.

Course 54
The Optometrist's Relationship to the Reading Program

Alfred A. Rosenbloom. Jr., O.D,
Chicago. Illinois
Helen M. Robinson, Ph.D.
Chicago. Illinois

A four-hour course—$8.00

Periods: W-10, W-11, W-2, W-3

The process of learning to read from the readiness period to maturity, with an opportunity to learn a new alphabet. Diagnosis of a retarded reader in which the contribution of the optometrist to the solution of the problem is clarified.

Course 55
Monocular Occlusion Testing

Raymond R. Roy, O.D.
Portland. Oregon

A two-hour course—$4.00

Periods: F-8, F-9

A detailed, illustrated presentation of a prolonged occlusion test, and its adaptation to clinical practice. Ample discussion of its application in migraine cases.

Course 56
Vision Screening in Industry

Herman Sager, O.D., M.S.
Lake Success. N. Y.

A two-hour course—$4.00

Periods: W-12, W-1

Techniques of vision screening programs for industry and their proper, efficient method of operation.

Course 57
Ocular Pathology Review Organized by Section on Pathology

Arthur Shlaifer, O.D., Chm.
Philadelphia. Pa.

A four-hour course—$8.00

Periods: W-E, T-E

Members of the Section will participate during the two two-hour evening periods. The chairman is author of a text in press, *"A Synopsis of Glaucoma for Optometrists,"* which will be the first of a series of home study courses for optometrists to be published for the Academy.

Course 58
Hypertensive and Arteriosclerotic Retinopathies

Harold Simmerman, O.D.
Wenonah. N. J.

A two-hour course—$4.00

Periods: W-8, W-9

Retinal geriatrics: illustrated lecture on the changes in the retina and choroid due to hypertension and arteriosclerosis and the attending sequalae. Also the grading of the retinal changes.

Course 59
The Design and Fitting of a Ptosis Crutch

Paul F. Shulman, O.D.
Chicago. Illinois

A two-hour course—$4.00

Periods: W-10, W-11

The problem of ptosis will be discussed relative to its eitology and prognosis. The specific procedure for fitting a ptosis crutch will be demonstrated on a patient. The different means of attachment of a ptosis crutch to various types of frames will be demonstrated and the different types of wire used will be exhibited. A ptosis crutch will be made in the classroom from start to its final fitting on the patient's face. Pictures of before - after results will be shown and discussed. Printed material outlining the procedure will be distributed.

Course 60
Space Eikonometer Technique of Measuring Aniseikonia

Donald A. Springer, O.D.
Anniston, Alabama

A one-hour course—$2.00

Period: W-4

This course will be devoted to the step-by-step procedure of measuring aniseikonia with the Space Eikonometer. The presentation will include not only the technique for usual patients, but also for more complicated cases which have difficulty in making reliable responses. The subject material will be essentially practical and based upon actual clinical experience. Specific questions germane to the technique of measuring aniseikonia will be discussed during the course.

Course 61
Comparison of Corneal Lenses

Charles R. Stewart, Ph.D.
Houston, Texas

A two-hour course—$4.00

Periods: F-8, F-9

Using the corneal "contour" concept described by Bier, the design and fitting characteristics of six types of corneal lenses are compared. This enables one to utilize the advantages of one lens over another in prescribing for contact lens patients.

Course 62
Early Detection of Pathology

Richard E. Talcott, O.D.
Mentor, Ohio

A two-hour course—$4.00

Periods: W-8, W-9

Early signs and symptoms, including a differential diagnosis of diseases of the external and internal eye.

Course 63
Ophthalmic Dispensing
Turner O. Veith, O.D.
Tenafly, N. J.

A two-hour course—$4.00

Periods: W-12, W-1

Interpupilary measurements, influence of correcting lenses on 'near P-d.' segment heights, angle of tilt of finished eyewear, coating of lenses, edge treatment and other important factors in the dispensing of eyewear.

Course 64
Accommodation and Refractive Errors
Gerald Westheimer, O.D., Ph.D.
Columbus, Ohio

A two-hour course—$4.00

Periods: F-2, F-3

New methods of measuring the refractive state of the eye will be discussed, including some automatic ones. Recent findings have some interesting implications in connection with the adjustment of the accommodative state of the eye and with the refractive error.

CONDENSED SCHEDULE OF COURSES

Course	Instructor	Subject	Hours	Periods
1	Allen	Subjective & Objective Refractive Instruments, $2	1	T-4
2	Allen	Physiological Optics—Entoptic Phenomena, $4	2	T-10, T-11
3	Allen	Efficiency and the Eye Examination, $2	1	F-4
4	Anapolle	Visual Training & Speed Reading, $24	6	W-E, T-E, F-E
5	Bebber	Accounting & Office Procedure, $4	2	T-2, T-3
6	Carter	Theory & Practice of Tonometry, $4	2	F-8, F-9
7	Copeland	Streak Retinoscopy, $8	4	W-E, T-E
8	Davis	Fundamentals of Aspheric Lenses, $4	2	F-10, F-11
9	Dick	Practice Management, $4	2	T-8, T-9
10	Dick	Accounts Receivable Control, $12	1	F-10
11	Dowaliby	New Trends in Cosmetic Dispensing $4	2	F-2, F-3
12	Dowaliby	Modern Plastic Lenses & Their Clinical Applications, $2	1	T-8
13	Eastman	Visual Acuity Testing Charts, $2	1	F-1
14	Feinbloom, Filderman & Williams	Sub-Normal Vision & Clinic	6	W-E, T-E, F-E
15	Feinbloom	The Physiological Optics of the Partially Blind Eye, $4	2	F-2, F-3
16	Firestone	Accommodation & Convergence with Contact Lenses, $4	2	T-8, T-9
17	Fry	Evaluation of Quality in Ophthalmic Lenses, $2	1	F-8
18	Fry	Vision Discomfort—Role of Glare Sources & the Pupil, $2	1	F-11
19	Graham, Feinbloom & Dickinson	Advanced Course on Corneal Lenses, $32	8	W-10, W-11, W-2, W-3, T-10, T-11, T-2, T-3
20	Grosvenor	Ocular Manifestations of Systemic Diseases, $4	2	T-12, T-1
21	Guth	Recent Advances—Illumination Requirements & Lighting Design, $4	2	T-E
22	Heath	The Badal Optometer, $2	1	T-1
23	Heath	Stigmatoscopy, $2	1	F-12
24	Heath	Office Use of the Recording Haploscope, $4	2	F-E
25	Hebbard	Visual Fields with Multi-pattern Test Targets, $2	1	T-9
26	Hebbard	Supplementary Methods of Investigating Heterophorias, $2	1	T-12
27	Hebbard	Flicker Fusion: Principles & Applications, $2	1	F-11
28	Hirsch	Refractive Changes Throughout Life, $4	2	W-10, W-11
29	Jankiewicz	Recent Advances in Ocular Anatomy & Neurology, $4	2	T-4, T-5

CONDENSED SCHEDULE OF COURSES

Course	Instructor	Subject	Hours	Periods
30	Jankiewicz	Microbiology in Contact Lens Practice. $4	2	F-4, F-5
31	Jaques	Binocular Nearpoint Testing Technique. $2	1	F-10
32	Jobe	The Care & Adjustment of Ophthalmic Instruments. $4	2	T-8, T-9
33	Knoll	Analysis & Use of Blended Bifocals. $2	1	F-6
34	Knoll	Use of Fresnel Lenses for Magnification. $2	1	F-7
35	Kratz	Diagnosis of Amblyopia vs. Central Scotomata. $4	2	T-10, T-11
36	Mark	Ocular Motility of the Clinical Level. $8	4	T-12, T-1, F-12, F-1
37	Mazow	Slit Lamp Microscopy in Contact Lens Practice. $24	6	W-4, W-5, T-4, T-5, F-4, F-5
38	Mazow	The Pupilens. $2	1	F-9
39	Morgan	Ophthalmic Prisms. $4	2	W-8, W-9
40	Morgan	Summary of Bangerter Technique for Train ng Amblyopia. $6	3	W-5, T-5, F-5
41	Morgan	Turville Infinity Balance Test. $4	2	T-10, T-11
42	Moss, I.	Corneal Contours in Contact Lens Practice. $4	2	W-E
43	Moss, I.	Astigmatism & Contact Lens. $4	2	F-E
44	Moss, L.	Contact Lens Records, Forms & Routine. $2	1	F-10
45	Moss, L.	Cosmetic Contact Lenses. $2	1	F-11
46	Neill, Dickinson & Associates	Technique of Microlens Fitting. $48	12	W-2, W-3, W-6, W-7, T-2, T-3, T-6, T-7, F-2, F-3, F-6, F-7
47	Ott	Legal Aspects of Optometric Practice. $4	2	W-8, W-9
48	Ott	Optometric Partnerships, Associateships, & Transfer of Practice. $4	2	W-2, W-3
49	Policoff	Adjustment & Modification of Contact Lenses. $24	6	W-12, W-1, T-12, T-1, F-12, F-1
50	Rayner	Basic Principles of Magnification as Applied to Aniseikonia Corrections. $4 (Prerequisite for Courses 51 and 52)	2	W-12, W-1
51	Rayner	Comprehensive Course on the Design of Aniseikonic Corrections. $4 (Prerequisite: Course 50)	2	T-2, T-3
52	Rayner	Simplified Procedure for Designing Istikonic Lenses. $4 (Prerequisite: Course 50)	2	F-12, F-1
53	Rosenbloom & Policoff	Subnormal Vision. $12	6	W-4, W-5, T-4, T-5, F-4, F-5
54	Rosenbloom & Robinson	The Optometrist's Relationship to the Reading Program. $8	4	W-10, W-11, W-2, W-3
55	Roy	Monocular Occlusion Testing. $4	2	F-8, F-9
56	Sager	Vision Screening in Industry. $4	2	W-12, W-1
57	Shlaifer	Ocular Pathology Review Organized by Section on Pathology. $8	4	W-E, T-E
58	Simmerman	Hypertensive & Arteriosclerotic Retinopathies. $2	2	W-8, W-9
59	Shulman	The Design & Fitting of a Ptosis Crutch. $4	2	W-10, W-11
60	Springer	Space Eikonometer Technique of Measuring Aniseikonia. $2	1	W-4
61	Stewart	Comparison of Corneal Lenses. $4	2	F-8, F-9
62	Talcott	Early Detection of Pathology. $4	2	W-8, W-9
63	Veith	Ophthalmic Dispensing. $4	2	W-12, W-1
64	Westheimer	Accommodation & Refractive Errors. $4	2	F-2, F-3

(See page facing inside back cover)

A mailing form for advanced registration for the American Academy of Optometry Post-Graduate Courses will be found on the page facing the inside back cover of this issue of this publication.

BOOK REVIEW

VISION SCREENING FOR ELEMENTARY SCHOOLS: THE ORINDA STUDY. Henrik L. Blum, M.D.; Henry B. Peters, M.A., O.D.; Jerome W. Bettman, M.D. Published by University of California Press, Berkeley, California. $5.00, 1959.

The Orinda Study, on which *Vision Screening for Elementary Schools* is based, was a three-year longitudinal study in an elementary school carried out under the leadership of a county public health officer. Parents, teachers, nurses, technicians, school officials, health officials, ophthalmologists, and optometrists all worked cooperatively, and the benefits of such cooperation stand out clearly. The results of the Orinda Study show how it is possible to overcome the serious deficiencies of several visual screening procedures currently used to identify children who need visual care. Included in *Vision Screening for Elementary Schools* is a realistic, practical, and efficient design for a vision program in elementary schools.

Other valuable contents of this publication include an excellent review of the literature on school vision screening; a cost analysis of visual screening; an analysis of a questionnaire sent to optometrists and ophthalmologists concerning criteria for referal; and nearly 100 references. It is of interest to note that comparison of the results of ophthalmological and optometric examinations of the children used in this study revealed no significant differences.

For several decades attempts have been made to devise tests which will rapidly and efficiently identify school children who need visual care. These tests have been administered by teachers, nurses, or mothers; sometimes by or with the help of optometrists and/or ophthalmologists. In reports of the results of such vision screening tests, none have a sufficiently high degree of efficiency: If a test picks out most of those who need visual care, it also fails many who do *not* need visual care; on the other hand, if the number of false failures is reduced, then many pupils who need visual care are missed. The procedures tested in the Orinda Study and reported in *Vision Screening for Elementary Schools* provide the basis for a vision testing program in which the efficiency of referal is exceptionally high.

It is noteworthy that to attain a high degree of efficiency it is necessary to have a "qualified" professional examiner (optometrist or

ophthalmologist) participate in the testing. None of several other procedures come close to producing the same high degree of efficiency. It appears also that accurate referal for refractive error requires retinoscopy as one of the screening tests.

Because of the importance of school children and school screening programs to optometry, *Vision Screening for Elementary Schools* should be read and studied by every optometrist.

COLLEGE OF OPTOMETRY
UNIVERSITY OF HOUSTON
HOUSTON, TEXAS

CHARLES R. STEWART, O.D., PH.D.

SPECIAL REPORT

GOLD IN OPTOMETRIC ATTICS*

Harriette M. Cluxton†
Illinois College of Optometry
Chicago, Illinois

Somewhere in a dusky attic lies a Treasure Trove. To an impatient housewife, it will look like a dusty pile of old books and magazines that should have been discarded years ago. To an optometric librarian, it may prove an exciting treasure, one literally without price.

At the outset, perhaps we'd better explain that the "gold" we are talking about is *not* coin of the realm. Our housewife would be lucky to get a few pennies from a waste-paper dealer for the whole stack! And finding a private purchaser would be next to impossible.

A book or a magazine is not necessarily valuable just because it is old. Nor is the original price paid for it, or even the usefulness to the original owner any indication of its worth. This fact is graphically illustrated, and all too frequently, when the optometrist's widow attempts to sell his professional library—ninety-nine times out of a hundred, composed of little except the textbooks he had in college, now out-dated by many, many editions.

An old book or magazine must be needed or wanted by someone, to make it valuable. In many fields of literature, there are dealers with real or prospective clients who will snap up certain old or rare books. An individual simply expresses his wishes to the dealer, who finds it and charges him for book and services. And dimes, quarters, and just plain old books may change hands in the second-hand bookstore, where one browses at will, perhaps many times over.

*Submitted on July 1, 1959, for publication in the August, 1959, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
†Librarian.

But in the field of optometric literature, a completely different situation prevails. The large used-periodical dealers rarely if ever list any optometric periodicals. And while it is possible that certain old books of optometric interest could be located by rare book dealers, none of the optometric college libraries have the funds to pay their fees. Their budgets barely cover current instructional needs. We are therefore appealing to you to dig out the "gold in optometric attics," and to get it into the hands of the optometric college libraries, where it can be both used and preserved.

Let's talk about the periodical "gold" first. It is incredible but true that none of the libraries serving the relatively young profession of optometry hold complete sets of all the major periodicals about it. The older colleges generally fare much better than the newer ones in this respect, as might be expected. The library from which we write was officially organized in 1930—roughly, half the life of the profession-ago—which makes us one of the older optometric libraries. Yet our collections in the 1930's are incomplete, and before that point, we have only scattered items.

Now, what was happening in the world of optometric periodicals in 1930? The AMERICAN JOURNAL OF OPTOMETRY (not yet the ARCHIVES) was already in volume 7 (but it is the first four or five volumes that seem impossible to obtain). The American Optometric Association was just starting its JOURNAL—and again, those first few volumes are desperately needed. The OPTICAL JOURNAL, with its differing heritage, had already gotten to volume 65, while the old WESTERN OPTICAL WORLD (now OPTOMETRIC WORLD) was in volume 18. OEP was taking its first long steps, using mimeographed materials.

Now, where are all those old magazines? Are they in *your* attic? Your father's? Your grandfather's?

Attempting to recover old state and regional journals is even more frustrating. These were usually considered as news bulletins, and rightly so—and hit File Thirteen soon after delivery. And the number of copies printed was usually small in the first place—not much more than the current membership list of the association involved. Then, the editors kept changing, and whatever official files there were, were usually weeded down to the bare minium with every transfer. Optometrists were too busy building practice and profession to realize that they were also making history, and that these small journals were recording it.

Buried in attic, cellar, or office file, somewhere, some of these old magazines may be found. It is just impossible to believe that all of them have ceased to exist. A little digging may bring them to light. These older magazines are needed by the optometric college libraries.

to fill out volumes and to complete their files, so that they may provide the materials for research and preserve the historical record of the profession. Very often, much more recent issues are needed: for binding purposes, to replace missing or worn issues, to provide multiple copies for reserve reading lists, and for exchanging with the other colleges for the copies they may want.

This last point is an important one. Through an agreement made in 1956 by the Association of Schools and Colleges of Optometry, its Library Committee assigned each member library the responsibility for collecting and preserving optometric periodical literature published within a certain region. A great deal of exchanging has already taken place, as each helps the other to build its files. This project is still going on, and now includes national optometric journals as well. (A project on foreign publications is being considered.) Often a few missing issues recovered in this way have made possible the binding of whole volumes of journals. A lucky gift of old magazines to one library has frequently profited others as well.

Among the pieces of "gold" shaped like books would certainly be the *Transactions of the American Academy of Optometry*, volumes 1, 2, 3, 4, and 8. The Clinical Research Reports printed by the Optometric Research Institute and the early practice management books by Ash are among the books which are hard to find. Certain books on vision and refraction by turn-of-the-century authors are historically valuable to optometric libraries. Very old optical catalogs are treasures indeed, as are some early instructional materials.

The book needs and interests of our libraries vary, but the ASCO system mentioned above makes it possible for an unwanted book related to optometric thinking or practice—or generally about the "eye"—to find a new home. Gifts to libraries should always be "with no strings attached," so that they may freely be used, exchanged, or distributed to interested students or faculty.

Here are some specific suggestions about handling the "gold in optometric attics":

1. Persuade the heirs of deceased optometrists to present their optometric books and periodicals to the college of their choice.

2. Discuss with retired optometrists the possibility of placing their collections in the hands of new generations of optometrists, through the libraries of the colleges who train them.

3. Make known to your family and heirs what your own wishes are, in this regard.

4. If you know the pleasure of haunting auctions and second-hand stores for a hobby, watch for "eye" books, and for old frames,

instruments, and other artifacts. Some of us are trying to build museum collections, without even the proverbial shoe string!

5. And think twice before you throw any optometric literature away. There may be "gold" in it! Even if it seems a bit tarnished, the optometric college libraries and the on-coming generations of students may have use for it. The college of your choice, and the ASCO Library Committee need your help in recovering the "gold in optometric attics."

3241 S. MICHIGAN AVENUE
CHICAGO 16, ILLINOIS

CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

NOTES FROM SCHOOLS AND COLLEGES

Construction has started on the new $600,000 addition to the Optometry Building at The Ohio State University. It will be four floors high, will house the Optometry Clinic, which will be expanded, particularly in the contact lens and orthoptics areas. In addition the building will contain various research laboratories, a mechanical optics laboratory, two classrooms, and three offices. It will be air conditioned and have an elevator. Completion is scheduled for January, 1961. . . . Dr. Frederick R. Kushner, Sheldon, Iowa, was re-elected national president of the ICO Alumni Association at the annual meeting held during the AOA Congress in Dallas. . . . Pacific University post-graduate seminar in Clinical and Experimental Optometry held its first annual conference and workshop at the College of Optometry, Pacific university, Forest Grove, Oregon, on July 24, 25, and 26, 1959. . . . A post-graduate course in Contact Lens Modification, taught July 25-27, was the first class held in the new University of Houston contact lens laboratory. . . . Twenty-six practicing optometrists recently completed a post-graduate course at Illinois College of Optometry in basic and advanced contact lens techniques.

The Foundation for Education and Research in Vision in conjunction with the University of Houston College of Optometry announces the third annual series of Study-at-Home Courses. FERV courses consist of 10 hours of instruction during a two-day period. To have a FERV course, six to ten optometrists get together and decide on one of the courses being offered. A University of Houston faculty member travels to their city, or to any location designated by the group.

He will bring with him all the necessary instructional materials and equipment needed for his course. Arrangements may be made to give the instruction in an optometrist's office, a hotel room, or in any place convenient for those taking the course. The cost of each course is $125.00 plus the instructor's travel expense and cost of incidental course materials. The following FERV courses are being offered this year:

1. Analytical Analysis of Optometric Data—Dr. Chester Pheiffer.
2. Color and Color Vision Testing—Dr. Chester Pheiffer.
3. Contact Lens Fitting and Modification—Dr. Herman Gerdes, or Dr. Charles Stewart.
4. Glaucoma and Scleral Tonometry—Dr. Theodore Grosvenor.
5. Graphical Analysis of Optometric Data—Dr. Darrell Carter.
6. Modern Clinical Optometry—Dr. Darrell Carter.
7. Neurophysiology of Vision—Dr. Chester Pheiffer.
8. Ocular Pathology—Dr. Theodore Grosvenor.
9. Refraction and Visual Examination Procedures—Dr. Darrell Carter.
10. Visual Fields Testing—Dr. Theodore Grosvenor.
11. Visual Training—Dr. Chester Pheiffer.

To schedule a FERV Study-at-Home course, or to receive further information write: Dr. Philip Lewis, Chairman, 8606 Jensen Drive, Houston 16, Texas.

NEW PRODUCTS

Liberty Optical Manufacturing Company announces a line of anodized lurium temples for men, women and children's frames. . . . American Optical Company has now in production a stereoscopic microscope attached to a heavy adjustable stand for clinical work. . . . The Shurtone Ronsir frame for men is the latest addition to the Browline collection. . . . The Univis Lens Company is now introducing a men's frame called the Invader. . . . The Bausch & Lomb Company have just placed on the market the B&L Cylinder Surfacer with external adjustment controls. . . . The B&L Company has also brought out a plastic frame for women called the Naya and a new Balrim aluminum frame for women in five colors. . . . The B&L Company has just issued a new Catalog #19 listing all of the eye protection products now made by the Company. . . . Plastic Associates are placing on the market a contact lens storage and carrying case called Hydra-Kit. . . . A contact lens with a microscopic lubricating opening in the exact center of the lens is being brought out by Quality Optics Laboratory. . . . Curry & Paxton have introduced the Tibbs Physiologic Diplopia Reader and the Tibbs Binocular Trainer as aids in orthoptic training procedures. . . .

IS THIS THE PROBLEM?

Irregular astigmatism, keratoconus, or aberrations of the corneal surface are conditions which will not allow patients to see things as they really are. The variations in curvature of the front surface of the cornea will refract light to different distances and in different directions. The spectacle lens will do very little to correct the irregular refraction of light by the cornea. Something is necessary to regularize the curvatures of the cornea. Proper fitting of a contact lens will take care of these conditions which are otherwise uncorrectable by any other means.

Uncorrected, the anterior and posterior surfaces of the precorneal fluid will conform to the surface of the cornea and maintain the irregular curvatures. With application of a contact lens, the front surface of the precorneal fluid conforms to the regular surface of the contact lens, thereby creating a spherical eye out of an originally distorted curvature.

In this way, patients with conditions which are often thought to be hopeless, can once again resume their work in a normal world with normal vision.

THE CONTACT LENS CIRCLE W/J

To the center of your contact lens problem

the Plastic Contact Lens Company

69 EAST MADISON STREET • CHICAGO 3, ILLINOIS

"Dedicated to Knowledge and Research"

With every correction

The call for neutral absorption enters into a surprising number of visual histories—whether as photophobia or as an occupational need. By its very nature it is often an elusive aspect of the patient's visual problem, but the extra comfort makes the extra consideration worthwhile. The need becomes critical in certain pathological conditions which cause photophobia, such as incipient cataract and keratitis, and in many myopic and aphakic conditions.

Although the fact of light-sensitivity is universally recognized, no objective test for it is known. Most refractionists have worked out a technique of their own involving subjective responses, along with a careful survey of the patient's visual tasks—especially occupational.

The Soft-Lite Demonstrator fits into these techniques perfectly, and makes it easy for you to show patients the effect of Soft-Lite shades 1 and 2 on their acuity and ease of seeing. Outlined below is a recommended procedure for

---

References:

Beacher, L. Lester. "Photophobia," Chap. XVII in *Ocular Refraction and Diagnosis*. New York, 1931.

Duke-Elder, Stewart. *The Practice of Refraction*. Third Edition. Philadelphia, 1938. Pp. 328-330.

Ferree, C. E. and Rand, G. "Examination and Care of the Eye in Relation to Lighting." *Archives of Ophthalmology*, Vol. 17 (January, 1937), pp. 78ff.

Fry, Glenn A. "The Evaluation of Discomfort Glare." *Illuminating Engineering*, Vol. 51 (November, 1956) pp. 722-728.

Holladay, L. L. "The Fundamentals of Glare and Visibility." *Journal of Optical Society of America*, Vol. 12 (April, 1926), pp. 271-319.

IES Lighting Handbook. Illuminating Engineering Society, New York, 1959.

Lebensohn, J. E. "Photophobia Mechanisms and Implications." *American Journal of Ophthalmology*, Vol. 34 (June, 1951), pp. 1294-1300.

Luckiesh, M. and Guth, S. K. "Brightness in Visual Field at Borderline between Comfort and Discomfort." *Illuminating Engineering*, Vol. 44 (November, 1949), pp. 650-667.

von Noorden, G. K. and Burian, H. M. "Visual Acuity in Normal and Amblyopic Patients under Reduced Illumination." *Archives of Ophthalmology*, Vol. 61, (April, 1959), pp. 533-535.

. . test for absorption

examining each patient for the need for absorptive lenses.

A careful testing procedure eliminates uncertainty.

1. Learn all you can about the lighting conditions under which the patient does his daily work. Direct glare over the working area, harsh contrasts or bright spots from light sources within the field of vision may keep the patient from enjoying the full benefit of his correction. Just recently lighting engineers have revised upward their foot-candle recommendations for occupational visual tasks (see list of references). This suggests that light-sensitive patients will need correspondingly greater attention.

2. Relate above findings to the results of the refraction, to determine whether neutral absorption may be a desirable fourth component in the prescription. Pay particular attention to high minus corrections and cases of sub-normal vision.

3. Use the Soft-Lite Demonstrator over the patient's correction, with a reading card or chart. Ask if patient notices improvement in clarity or comfort of Soft-Lite shade 1 over white, and shade 2 over white. Often small improvements in acuity appear at this point. The test helps to identify light-sensitivity where it is one of a group of sub-threshold factors which together produce a complaint.

4. Discuss with the patient the function of neutral absorption in his prescription—its contribution to his comfort—and explain also the cosmetic features of absorptive lenses.

For a detailed exposition of this procedure for testing for neutral absorption, write to Bausch & Lomb Optical Co., F-064, Rochester 2, N. Y., for B-1110, "The Place of Neutral Absorption in Your Practice."

F. W. Jobe.

Bureau of Ophthalmic Research and Development

BAUSCH & LOMB

Testing with the Soft-Lite Demonstrator helps to identify light-sensitivity. Includes shades 1 and 2.

Every patient that has been prescribed Therminon enjoys the comfort and it seems to alleviate complaints of retinal sensitivity . . .

One in a series of professional evaluations of Therminon Lenses. Name and address on request.

Therminon LENSES

THERMINON LENS CORPORATION • 63RD AT UNIVERSITY • DES MOINES, IOWA

An
ACADEMY MEMBERSHIP PIN

10K Gold

The Emblem of the Academy

in a round, gold and blue enamel pin, 13 mm. in diameter, with safety catch.

Mailed Post-Paid

$3.50
to members only

Send orders to

AMERICAN ACADEMY of OPTOMETRY

1506-1508 Foshay Tower
Minneapolis 2, Minnesota

ANNOUNCEMENT BY
Illinois College of
OPTOMETRY

Applications for admission to classes beginning September 8, 1959 are now being received.

Three year course
of professional study
Leading to the Degree of
Doctor of Optometry

Requirements for Entrance:
Two years (60 semester hours or equivalent quarter hrs.) in specified liberal arts and sciences.

WRITE FOR BULLETIN
TO: REGISTRAR
ILLINOIS COLLEGE
of OPTOMETRY
3241 So. Michigan Ave.
Technology Center, Chicago 16, Ill.

Continental's Great Combination Frame for Men – *Now in Lurium*

Modish, lightweight Lurium top arms and skull temples combine with the stout 1/10 12K gold-filled chassis to bring new lift and polish to the clean-cut good looks of Mansfram, Continental's combination frame success.

Colors, gray and brown. Detachable type crystal pads. Clear crystal temple tips. Eye sizes, 44-46-48. Bridge sizes, 18 to 26.

MEMBER OF UPPER MIDWEST COUNCIL FOR BETTER VISION

MINNESOTA OPTICAL CO.

Exclusive Supplier for the Profession

621 West Lake St., Minneapolis 8, Minn.

SATISFYING RX SERVICE

is the infusion of many important elements

The use only of recognized quality products
Modern equipment and precision machinery
Highly skilled and experienced workmanship
Sales policies constructive for the Profession

The maintenance of a rigid inspection system in the processing of your prescriptions
A personal friendly Rx service adapted to your Optometric needs

TWIN CITY OPTICAL COMPANY

MINNEAPOLIS MINNESOTA WILLMAR

49 Years of Quality First

WATCHEMOKET
optical accessories

"STANDARD OF THE INDUSTRY"

BLACKOUT RETRAINING INSTRUMENT

For retraining eyes after retinal detachment operations . . . all plastic construction . . . staggered pinhole openings with P. D. range of 58 mm to 73 mm . . . "Blackout" lens and frame exclude light which weakened retina cannot comfortably accept . . . deep frame accommodates surgical dressings.

WATCHEMOKET eye SAVERS

WATCHEMOKET OPTICAL CO., INC.
232 West Exchange Street • Providence 3, R. I.

WALCO

SINCE 1915

COMPLETE OPHTHALMIC *Services* to the PROFESSION

☆ *Precision* GRINDING
☆ *Quality* MATERIALS
☆ *Craftsmanship*

CONVENIENTLY LOCATED
St. Paul, Minn. • Austin, Minn. • Bemidji, Minn.
Watertown, S.D. • Grand Forks, N.D.

THE WALMAN OPTICAL COMPANY
229 Medical Arts Building Minneapolis 2, Minnesota
FOUNDED IN NINETEEN HUNDRED FIFTEEN

TO AVOID DISAPPOINTMENT

and be sure of getting the

Courses you wish to take —

fill out the

ADVANCE ORDER SHEET

on the next page and mail to

Dr. D. G. Hummel
1318 National City Bank Bldg.
Cleveland, Ohio

Complete Microfilm Reels of the entire contents of the
AMERICAN JOURNAL OF OPTOMETRY and ARCHIVES of AMERICAN ACADEMY OF OPTOMETRY
are available by annual volumes (or years), at low cost, fr.m the
UNIVERSITY MICROFILMS
313 N. First St. Ann Arbor, Michigan
Write for prices - Immediate shipment

★ Indispensible for Accurate Fits
★ Wide Selection of Cone Shapes
★ Sturdy Heaters, Incl. Red "On" Signal

Interchangeable
CONES and HEATERS
Write for Complete Catalog!

APEX QUALITY **SPECIALTIES CO.**
1105 Douglas Ave.
Providence 4, R. I.

FOR ADVANCED REGISTRATION

AMERICAN ACADEMY OF OPTOMETRY

CHICAGO, DECEMBER 9, 10, 11, 1959

DRAKE HOTEL

Applications should be made to Dr. D. G. Hummel, 1318 National City Bank Bldg., Cleveland 14, Ohio. One-half of the total fee for courses with non-limited attendance and *the entire fee for each course with limited attendance must accompany the application.* The balance must be paid at the commencement of courses. Without exception, everyone enrolled in courses must register and pick up appropriate tickets for each course. Without them, no one can be admitted. Acceptance of applications will be on a first come first serve basis. When the number allowable in any course is filled, applications will be received on a contingent basis and used in case of cancellation. In case of cancellation the fee will be returned, providing such cancellation is received no later than November 21, 1959.

Advance Order Sheet

Please indicate courses you wish to take.

No. of Course	Instructor	Hours	Total Fee	Date	Time

Name _____

Address _____

City _____ State _____

For Use of the Committee on Administration

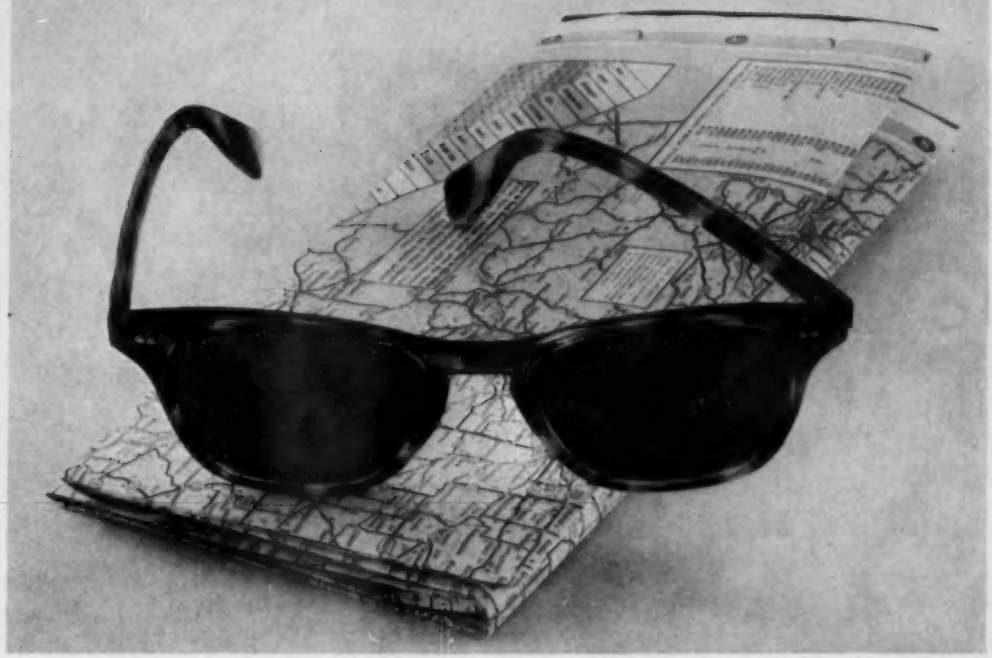
Deposit _____ Balance _____

Date Received _____

Notified _____ Date _____ Accepted _____ Contingent _____

CUT HERE AND MAIL

the case for UNIVIS *Light Control*®



Your best tool in prescribing UNIVIS *Light Control*® lenses

It's simple. Buy yourself one or two pairs of dime store sunglasses. When you've finished your examination, turn on the bright lights and slip a pair on your patient, hand him something to read, and ask this simple question: "Would you like as good vision with your *sunglasses* as you'll have with your new lenses which I've just prescribed for you?"

In many cases, your next step will be to help him select the proper shade of Univis Light Control prescription sunwear to suit his particular visual needs.

Every patient? Of course not. No more than every auto buyer wants white sidewalls or a radio. But you'll be surprised how many will say "yes!" Send for free descriptive material.

® Trade-mark of The Univis Lens Company

UNIVIS
Light Control®
lens series

UNIVIS

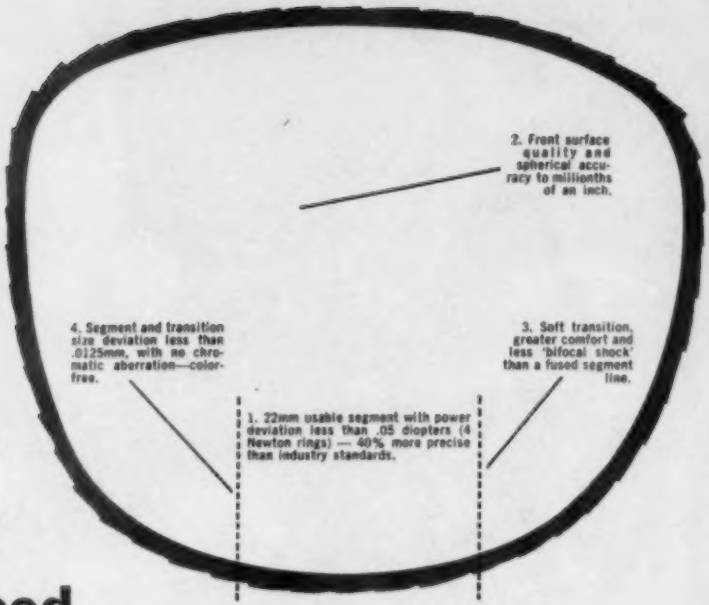
The Univis Lens Company, Dayton, Ohio
Professional Services Division

Please send descriptive booklet on Univis Light Control

Name_____

Address_____

City_____ State_____


2. Front surface quality and spherical accuracy to millionths of an inch.
4. Segment and transition size deviation less than .0125mm, with no chromatic aberration—color-free.
3. Soft transition, greater comfort and less 'bifocal shock' than a fused segment line.
1. 22mm usable segment with power deviation less than .05 diopters (4 Newton rings) — 40% more precise than industry standards.

...so we took back every pair and replaced them with the new YOUNGER-22 SEAMLESS LENS!

This was the case last October when we offered to exchange all laboratory stocks of Younger Seamless Lenses manufactured prior to October, 1958.

A major breakthrough in quality and precision, achieved after twelve years of constant and continuous development, research and engineering, has permitted the manufacture of a vastly improved, seamless dual-field lens with a full 22mm usable segment with less than .05 diopter power deviation; a front surface accuracy to millionths of an inch and a segment-size deviation of less than .0125mm!

Because of the unsurpassed quality of the new Younger-22 Seamless Lens, the decision was made to replace all existing Younger stocks.

We are grateful to the thousands of professional men who have continued to prescribe the very acceptable Younger Seamless Lens during the period of its development; *they* know today how much better the new lens is!

If you haven't prescribed a Younger Lens since this past October, you are missing one of the most significant advances in lens manufacture of the past decade.

Remember: you do not take the slightest risk when you do so, for if the patient cannot wear Youngers for any reason, your independent supplier will replace it with a fused bifocal of your choice at no additional cost.

Write on your letterhead for a sample of the vastly improved Younger-22 Seamless Lens. There is no charge, but please give us the name of your independent supplier.

YOUNGER

1829 SOUTH MAIN STREET
LOS ANGELES 15, CALIF.

INTERESTED IN A SIMPLE, DIRECT PRESENTATION OF THIS UNUSUAL LENS TO YOUR PATIENTS? WRITE FOR THE STORY!